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THE POWER PLANT OF THE ST. LOUIS EXHIBITION.

One of the most important and most interesting of the engineering features of the Louisiana Purchase Exhibition is the power plant furnishing electric current for the various lighting and power purposes. This power plant comprises some 30 engines, with an aggregate of 35,000 HP., and the largest unit is the Allis-Chalmers vertical-horizontal compound engine of 5,000 HP., directly connected to a Bullock generator of 3,500 KW. There are two types of steam turbines (Curtis and Hamilton) one triple-expansion engine (Bradley-Willans), and one quadruple-expansion engine (Delaunay-Belleville).

At the Columbian Exhibition, at Chicago in 1893, the power plant was composed of 60 engines aggregating about 25,000 HP., and the largest unit was a Reynolds-Corliss quadruple-expansion horizontal engine of 2,000 HP., belted to two generators. There were also seven engines of 1,000 HP., one of which was of foreign construction. This power plant was described in our issues of July 20 and Aug. 24, 1893; and a 2,500 HP. four-cylinder triple-expansion vertical engine at the Paris Exhibition was illustrated in our issue of June 21, 1900.

Of the 16 engines of largest size at St. Louis, 10 are of the Corliss type; 7 are vertical (Westinghouse, Hamilton and Brown); 2 horizontal (Lane & Bodley and Murray), and 1 combined vertical and horizontal (Allis-Chalmers). Of the other American engines, three are horizontal (Buckeye, Harrisburg and Greenwald), and one is vertical (Bradley-Willans). Of the two foreign engines, one is vertical (Delaunay-Belleville) and the other is horizontal (Société Alsacienne). All electric generating units, whether large or small have the engine and generator directly connected, there being no belted generators.

The power plant may be divided into two groups: 1, The service plant purchased by the exhibition company; 2, The plant composed of engines, generators, boilers and auxiliary apparatus exhibited by various firms, and grouped together to form complete units. The latter may be subdivided into two sections, one of which is for general purposes, while the other forms the power plant of the electric intramural railway. It was at first intended to supplement the power plant by taking 6,000 KW. from the new power station of the Union Electric Light & Power Co., but this has not been done, as the plant is of ample capacity in itself.

Mr. Henry Rustin was chief mechanical and electrical engineer for the exhibition company during the early stages of construction, but was compelled to resign on account of ill health. He was succeeded by Mr. Edward B. Ellicott, M. Am. Soc. M. E. (City Electrician of Chicago). Mr. H. F. Smith was Assistant Mechanical Engineer, and Mr. W. M. Dixon, Assistant Electrical Engineer. The accompanying table gives a list of the engines and generators.

SERVICE POWER PLANT.

The exhibition company found that it would be necessary to install a power plant of its own, to be under its direct control, and a contract for the design and installation of the entire plant was let to Westinghouse, Church, Kerr & Co., of New York. The engines were built by the Westinghouse Machine Co., and the electrical equipment by the Westinghouse Electric & Mfg. Co., except that two of the four main generators were built by the General Electric Co. The service includes the supply of current for arc and incandescent lighting, and for power purposes. The distribution is by three-phase current, at a potential of 6,600 volts, with a frequency of 3,000 alternations per minute, or 25 cycles per second. A conduit system carries the high-tension cables to substations in the buildings, where the alternating current is stepped down to voltages suitable for distribution or converted to direct-current for motor work.

The main generating plant consists of four Westinghouse-Corliss vertical cross-compound engines of 3,200 HP., each directly connected to an alternating-current generator of 2,000 KW. capacity. It is arranged in two groups, each with its own boiler battery, mechanical draft, steam main and condenser system. The engines are described below. The two Westinghouse generators have the following guaranteed efficiency, based upon measured iron and copper losses; full load, 96%; three-quarter load, 95%; half load, 93%. Their revolving fields are strap wound, with laminated pole pieces. The three exciter units (one of which is for reserve) have field frames in two parts, which can be drawn apart (at right angles to the shaft) to give access to the armature. Each of these units is directly connected to a compound engine with cylinders 12×12 and 20×12 ins. The switchboard has 35 panels; 1 for each of the main generators and exciters, 2 for load (with a duplicate set of bus-bars) and the rest for outgoing feeders. The main current is controlled entirely by automatic oil switches, electrically operated from the main switchboard. Shunt and series transformers are used with all indicating and recording meters.

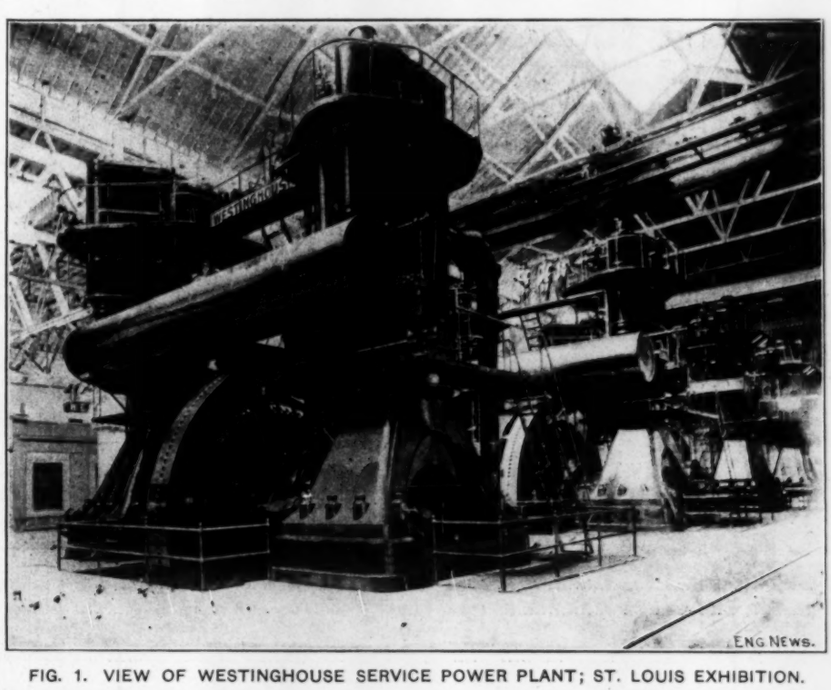


FIG. 1. VIEW OF WESTINGHOUSE SERVICE POWER PLANT; ST. LOUIS EXHIBITION.

The boiler plant consists of 16 Babcock & Wilcox water-tube boilers of 400 HP., arranged in pairs, and fitted with the Roney mechanical stokers driven by small steam engines through worm gearing. Steam is supplied at 150 lbs. pressure. Coal from West Virginia mines is brought to the exhibition daily by special cars, which are run into the boiler house on two tracks and dumped into hoppers with short lateral conveyors to a pair of crushers. A system of the Link-Belt Machinery Co.'s conveyors and elevators carries the coal to a 500-ton storage bunker or to the individual hoppers which supply the stoker magazines. The ashes fall into concrete pits, and are hauled away in small cars running in tunnels leading to an underground chamber with an ele-

vator, discharging the ashes into railway cars on a sidetrack outside the building.

Mechanical draft is used, with comparatively short iron smokestacks 11 ft. diameter. The flues leading to the fans are formed by the 10-ft. space between the rear walls of the boilers, having a concrete floor and brick roof. A row of 4-in. pipe columns in the middle carries a line of I-beams with transverse T-bars between the walls, and these bars support the roof. For each of the two sets of boilers there are two 14-ft. steel plate fans, with 12 blades, built by the New York Blower Co.; these revolve in opposite directions, delivering the gases into the central chamber leading to the smokestack. The fan bearing is protected from the heat of the flue gases by a water jacket. Each fan is directly connected to a horizontal automatic engine without flywheel, running at varying speeds according to the draft required. Each engine has a cylinder 13 x 14 ins., with a balanced slide valve, double-ported for both steam and exhaust. This valve is worked from a vertical rocker arm operated by the eccentric rod. The crank bearing has babbitt metal extending all around the surface, and is designed to prevent heating even under heavy loads and for long runs. It is self-centering and self-oiling, and the lining shells can be removed without disturbing the shaft. These engines were built by the Chandler & Taylor Co., of Indianapolis, Ind.

The feed water, taken from the city mains, is passed through Cochrane feed water heaters, using exhaust steam from the auxiliary engines. The two condensers are of the Worthington elevated jet or barometric type with 40-in. entrance, and a 20-in. riser to the condenser cone, which has a tubular air cooler, around which the injection water circulates on its way to the condenser. The entrained air, which would impair the vacuum, is drawn from the condenser cone as saturated vapor by means of dry-vacuum pumps, and the moisture is condensed in the air cooler. The dry-vacuum pumps are of the new Worthington high-speed rotative type, with oil lubrication and clearance spaces reduced to a minimum. The steam and vacuum pistons are mounted on the same rod, and the steam distribution is controlled by a slide valve with an adjustable eccentric to vary the point of cut-off according to the steam pressure. The suction air valve is also a slide valve, driven by an eccentric and on top of the balancing plate of this valve rides the discharge valve; this is adjustable from the outside by means of a hand wheel, so as to open and close the discharge at any position of the piston from half to full stroke, depending upon the amount of air handled and the desired vacuum. A number of small poppet relief valves on the back of the balancing plate open automatically when the cylinder pressure exceeds atmospheric pressure, in the event of unusual leakage or a broken pipe causing the entrance of a large volume of air. The overflow from the condenser hot wells flows to a main concrete hot-well at the cooling towers. There are four of these towers, built of brick, rectangular in plan and 52 ft. high. Each contains 10 tiers of wooden gratings, each 24 ins. high, alternate gratings being at right angles to each other. These occupy 20 ft. of the height, and have a 12-ft. space beneath for the fan chambers and a 20-ft. space above to carry the vapor above the roofs. Each tower has a 20-in. pipe supplying 30 transverse distributing pipes having holes drilled on the under side. Under each tower is a settling tank connecting with the cold-well from which the condenser water is taken. The draft for each tower is supplied by four 10-ft. Seymour fans, belted to a shaft. There are three 24-in. Worthington turbine centrifugal circulating pumps; one for the two condensers, one for the cooling towers and one for reserve. Each has a capacity of 17,000 gallons per minute, under 50 ft. head.

The eight boilers of each group are connected by a 10-in. main and a 4-in. auxiliary, each in the form of a ring main, and with valves so arranged that in case of rupture one half of the main can be shut off and the other kept in service. The distance from the ring main in the boiler house to the engines in the Machinery Building is 464 ft. for one group and 617 ft. for the other. The pipes are laid in a tunnel, and the expansion in these long lines is provided for by sufficient radius at the bends and by anchoring the pipes at intermediate points. The measured expansion in the longest line was 16⅝ ins. The entire high-pressure piping system in the boiler house, including the water pockets of the valves, is drained by a steam loop and Holly gravity return system, automatically returning the water of condensation to the boilers.

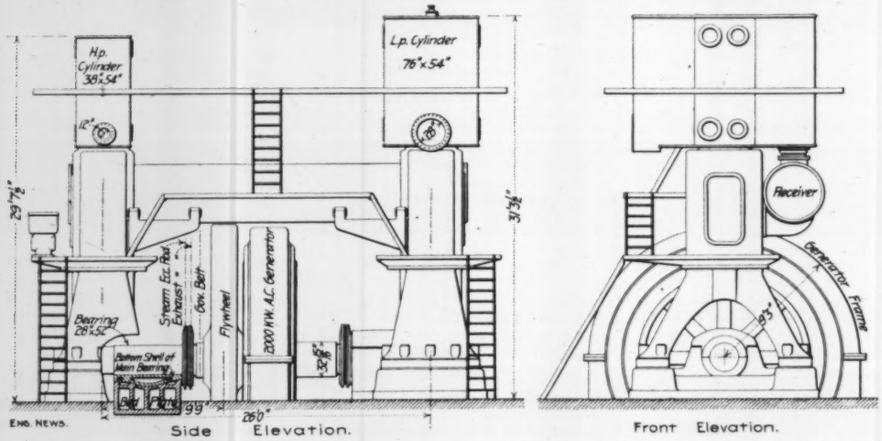


FIG. 2. ELEVATIONS OF 3,200-HP. VERTICAL CROSS-COMPOUND CORLISS ENGINE; ST. LOUIS EXHIBITION.
Westinghouse Machine Co., Pittsburg, Pa.

THE WESTINGHOUSE ENGINES.—The four

POWER PLANT OF THE ST. LOUIS EXHIBITION.

	ENGINES. Builders.	Type.	Cylinders, ins.	Revs.	HP.	GENERATORS. Builders.	Type.	K.W.
1-4	Westinghouse Machine Co., Pittsburg	4 vert. cross comp. Corliss, 3,200 HP	38 and 76 x 54	83.3	12,800	Westinghouse Elec. Co., Pittsburg... / General Elec. Co., Schenectady, N. Y.	2 alternators, 6,600 volts, 2,000 k.w. / 2 " 6,600 " 2,000 "	8,000
5-7	Westinghouse Machine Co., Pittsburg	3 vert. comp., 120 HP	12 and 20 x 12	....	360	Westinghouse Electric Co., Pittsburg..	3 d. c., 80 k. w., 125 volts	240
8	Allis-Chalmers Co., Chicago	Hor. and vert. cross-comp. Corliss	44 and 94 x 60	75	5,000	Bullock Electric Co., Cincinnati	Alternator, 6,600 volts	3,500
9	Hooven, Owens, Rentschler Co., Hamilton, O.	Vert. cross-comp. Corliss	34 and 68 x 54	83	2,250	National Electric Co., Milwaukee	Alternating current	1,500
10	C. H. Bradley, Jr. & Co., Pittsburg	Willans trip. exp. vert.	13⅜ and 20⅞ and 32¼ x 13⅜	277	1,000	Stanley Electric Co., Pittsfield, Mass...	Alternator, 2,300 volts	600
11	C. H. Bradley, Jr. & Co., Pittsburg	Willans comp. vert.	8½ and 12 x 6	470	50	Northern Electric Co., Madison, Wis...	110 volts, d. c.	30
12	I. & E. Greenwald, Cincinnati.	Hor. cross-comp. 4-valve...	18 and 36 x 42	100	600	Ft. Wayne Electric Co., Ft. Wayne, Ind.	250 volts, d. c.	400
13	A. L. Ide & Sons, Springfield, Ill.	Hor. tand. comp.	13 and 26 x 18	....	300	Bullock Electric Co., Cincinnati	250 volts, d. c.	200
14	American Engine Co., Bound Brook, N. J.	Hor. duplex comp.	14 and 22 x 16	230	200	Am. Eng. Co., Bd. Bk., N. J.	125 volts, d. c.	125
15	Skinner Engine Co., Erie, Pa.	Hor. simple	18 x 18	....	200	Warren Electric Co., Sandusky, O.	2,500 volts,	150
16	Buffalo Forge Co., Buffalo, N.Y.	Hor. tand. comp.	13 and 22 x 14	225	175	Stanley Electric Co., Pittsfield, Mass...	2,400 volts,	132
			FOREIGN.					
17	Societe Delaunay-Belleville, St. Denis, France	3 Vert. quad. exp.	13.6 x 18.8 / 27.2 x 18.8	335	1,500	Soc. l'Eclairage Elec., Paris, France....	Alternator, 2,300 volts	1,000
18	Societe Alsacienne, Paris, France	Hor. tand. comp	24 and 44 x 52	94	1,000	Soc. Alsacienne, Paris	Alternator, 2,100 volts	700
19	General Elec. Co., Schenectady, N. Y.	Curtis vert. shaft	....	750	3,000	General Electric	Alternator, 6,600 volts	2,000
20	Hooven, Owens, Rentschler Co., Hamilton, O.	Hamilton, horiz. shaft	....	1,500	1,500	Bullock Electric Co., Cincinnati	Alternator, 6,600 volts	1,000
			GAS ENGINE.					
21	Weber Gas & Gasol. Eng. Co., Kansas City, Mo.	Vert. with producer	....	....	125	....	Direct current	75
			AIR COMPRESSOR.					
22-23	Laidlaw, Dunn, Gordon Co., Cincinnati	Two horizontal compressors; displacement 1320 and 530 cu. ft.	....	....	....	....	....	....
			INTRAMURAL RAILWAY.					
24-25	Brown-Corliss Eng. Co., Corliss, Wis.	2 vert. cross-comp Corliss, 750 HP	18 and 36 x 36	135	1,500	Crocker-Wheeler Co., Ampere, N. J.	550 volts, d. c.	1,000
26	Buckeye Eng. Co., Salem, O.	Hor. cross-comp. piston valve	26½ and 50 x 40	100	1,400	" " "	550 " "	900
27	Lane & Bodley Co., Cincinnati.	Hor. cross-comp. Corliss	20 and 40 x 54	85	900	" " "	550 " "	600
28	Murray Iron Works Co., Burlington, Ia.	Hor. simple Corliss	26 x 48	100	750	" " "	550 " "	500
29	Harrisburg Fdy. & Mach. Wks., Harrisburg, Pa.	Hor. tandem comp., Fleming, 4-valve	15 x 40½ x 26	....	600	" " "	550 " "	400
30	Abner Doble, San Francisco, Cal., and Jeanesville Iron Works Co., Jeanesville, Pa.	Double impact water-wheel and Jeanesville triple exp. pump for 300 lbs.	....	700	160	" " "	550 " "	100
	Totals				35,370			23,152

large Westinghouse engines form a striking and attractive group. A general view is shown in Fig. 1, while Fig. 2 gives elevations of one of the engines. They are vertical cross-compound condensing engines, rated at 3,200 HP., with a maximum capacity of 4,800 HP., and each has mounted on its shaft the revolving field of an alternating current generator of 2,000 KW. The cylinders

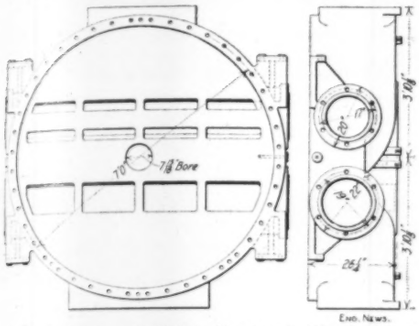


Fig. 3. Lower Cylinder Head of Westinghouse Engine.

are 38 × 54 ins. and 76 × 54 ins., placed 26 ft. apart c. to c., and the height from floor level to top of cylinder is 31 ft. 3½ ins. The engines run at a speed of 83.3 revolutions per minute, giving a piston speed of 750 ft. per minute. They take steam at 150 lbs. pressure at the throttle, and have a back pressure of 2 lbs. absolute (vacuum 26 ins.). The receiver capacity is 436 cu. ft. and the cylinder displacement per minute is 5,920 cu. ft. for the high pressure and 23,650 cu. ft. for the low pressure. The guaranteed economy is 13.5 lbs. per I. HP. per hour, based upon a mean effective pressure (referred to the low pressure cylinder) of 27½ lbs. when running with 26 ins. vacuum. Each engine occupies 532 sq. ft. of floor area. The following is a description of one of these interesting engines:

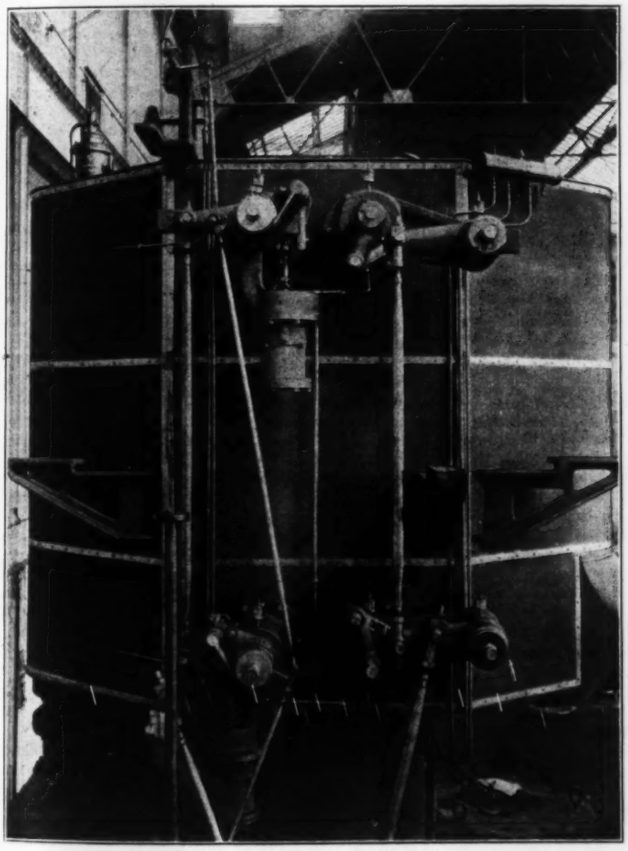


FIG. 5. VALVE GEAR.

The cylinders and guides are supported on heavy A-frame housings, which are split along the central vertical plane to facilitate shipment and erection. These frames are anchored to the foundations by bolts passing through the bed plates. The cylinders have steam and exhaust pipes cast independent of the cylinder proper, contraction and expansion being provided for by corrugated copper expansion joints. The valves and ports are located in the cylinder heads, as shown in Fig. 3. The guides are single castings, with the wearing surfaces cooled by water circulation. The pistons are of cast iron, of box pattern, fitted with sectional packing rings set out by springs. Their rods are screwed into the pistons and crossheads, and are secured by jamb nuts with keepers. The crossheads are of cast steel, fitted with adjustable shoes faced with babbitt, and the inner and outer surfaces of the shoe are made concentric, so that by removing the screws the shoes can be slid out of place without disturbing the crosshead. The crosshead pins are 11 × 13 ins., with tapered end fits. The connecting rods are 11 ft. 3 ins. long, c. to c. of bearings; they are of circular section with solid ends fitted with phosphor-bronze boxes adjusted by wedges. The castings for all parts having interior rubbing surfaces subjected to high pressure, such as the cylinders, pistons, and valves, are made of air-furnace iron, cast in an open-hearth furnace. This is much harder than ordinary cupola iron, has a closer grain, and about 30% greater fiber strength. This iron is also used for the flywheel centers on account of its greater tensile strength. Cupola iron is employed for bed plates, housings, guides and other parts where the special characteristics of the air-furnace iron are not so important.

The crank pins are 13 × 13 ins., forced into cast steel fantail cranks, with taper fit, and have the ends riveted over behind the crank disk. These cranks are set at 90°, and have taper fits on the ends of a fluid-compressed, hollow-forged open hearth steel shaft, 24 ft. 11 1-16 ins. long, having a bore of 12 ins. It is 33 ins. maximum diameter, 31 ins. at the flywheel and generator seats, and 28 ins. at the main bearings, which are 4 ft. 4 ins. long. These bearings are of the two-part self-aliining type, with water circulation in the lower shells. The lower shell rests on a hemispherical seat in the bed plate (as shown in Fig. 2), and the upper shell serves also as a cap, having shoulders which engage with projections on the lower part of the bearing, and thus link the two sides together. By removing this cap and easing the shaft off its seat, the lower shell may be rotated so as to be removed for re-babbitting. The adjustment of the bearings is by means of shims. The flywheel, Fig. 4, is 22 ft. diameter, with its rim built up of five segments, each cast with two arms. These segments have the ends faced and are held together at the rim by T-head shrunk links. The hub is composed of a pair of heavy disks or cheeks, 8 ft. 6 ins. diameter, keyed to the shaft and embracing the ends of the wheel arms, each arm being held by three 3-in. through bolts. The weight of the flywheel is 189,000 lbs., and the flywheel effect (weight of rim × radius of gyration²) is 13,110,000 (in feet and pounds). The weight of shaft, crank disks and crank pins is 87,222 lbs.

The valves are of the Corliss double-ported type, located in chambers in the cylinder heads and held against their seats by spring shoes. The valve gear, Fig. 5, is of the Corliss type, with two eccentrics to each cylinder, but no wrist plates are used. The steam eccentric rod operates a rocker

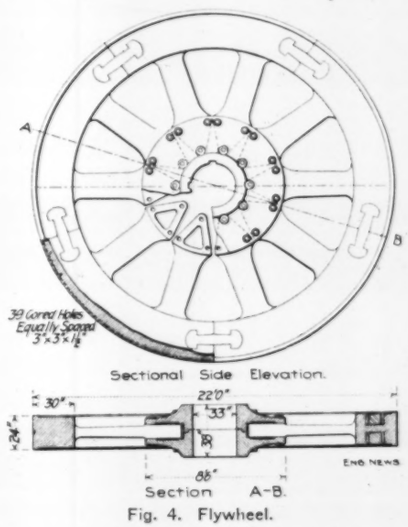


Fig. 4. Flywheel.

arm on a shaft having another arm to which is attached the extension or carrier rod; this is in turn attached to a rocker arm, which operates the lower valve and has on its shaft a second arm carrying the carrier rod which is attached to the arm of the upper valve. The exhaust eccentric operates the carrier rod of the lower valve in the same way, but here there is a toggle joint motion in connection with the rocker or wrist arm to ensure a quick opening and closing of the valve. The steam valves have a trip release gear, operated from the governor lay shaft, and having a range of cut-off of 0 to ¾ stroke. The dash pots are not attached to the cylinders, but are integral with and hung from the valve bonnets. With underhung dash-pots, it is claimed that the stress due to the suction of the pistons is entirely absorbed by the solid connection between the bonnet and dash-pot, thus relieving the former from the bending stress, which is said to cause flexure in some of the old forms of Corliss gear.

The governor is of the high-speed centrifugal type, completely enclosed. In order to facilitate

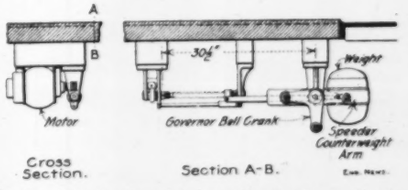


Fig. 6. Speeder Regulator on Westinghouse Engine.

paralleling the generators and to distribute the load between the several units, the cut-off may be adjusted while running by means of a "speeder," consisting of an adjustable weight on a lever arm keyed to the governor lay shaft. This is shown in Fig. 6. The position of this weight may be changed as desired by a small series motor controlled from a switch on the generator panel of the switchboard. The motor operates a revolving nut on a horizontal threaded rod connected to the weight. The position of the weight and the moment or torque on the governor lay shaft may thus be varied, which is equivalent to loading or relieving the governor spring so that the cut-off is varied in proportion. With a unit running by itself, the "speeder" would simply cause a variation in speed, which is of value in bringing up a machine to parallel with one already running. When they are in parallel, however, it is

not possible to vary the speed of one unit without pulling the other one up to it, so that the effect of varying the cut-off is then entirely evidenced by a shifting of load from one machine to the other. Thus, speeding down one generator relieves it of load, and speeding it up makes it take load from the other machine. As these motors are all controlled from the switchboard generator panel, it is evident that the most delicate control of the generating units can be effected from this point.

The throttle valve is 16 ins. diameter, with a pilot valve in the center to admit steam for warming up the engines, and to relieve the pressure by acting as a by-pass before the main valve is opened.

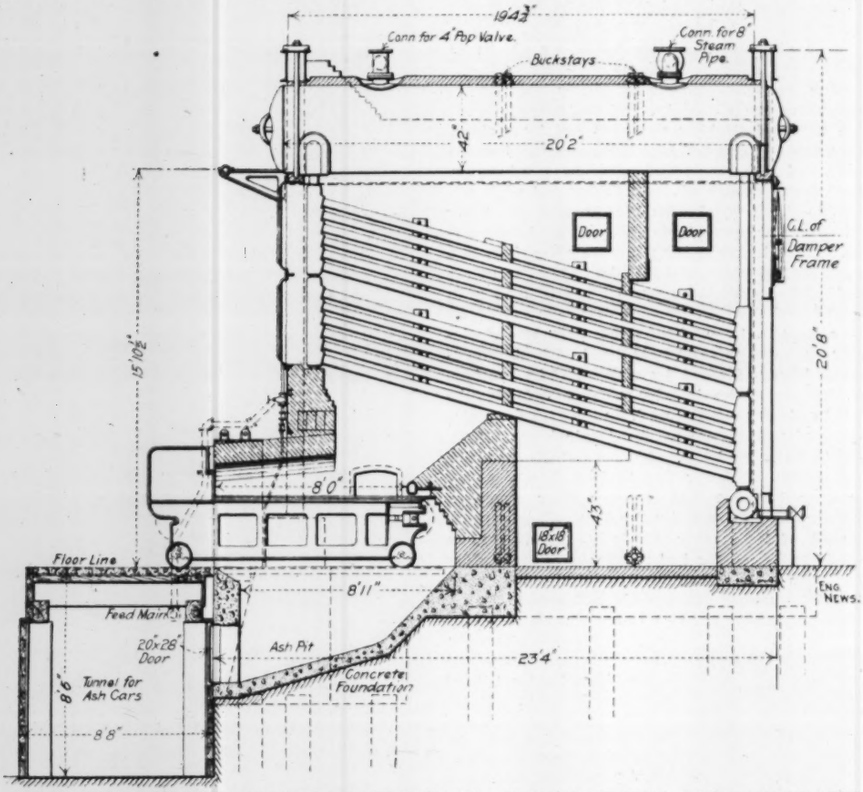


FIG. 7. CAHALL WATER-TUBE BOILER AT THE ST. LOUIS EXHIBITION; SHOWING ASH-PIT AND TUNNEL FOR ASH CARS.
Aultman & Taylor Machinery Co., Mansfield O.

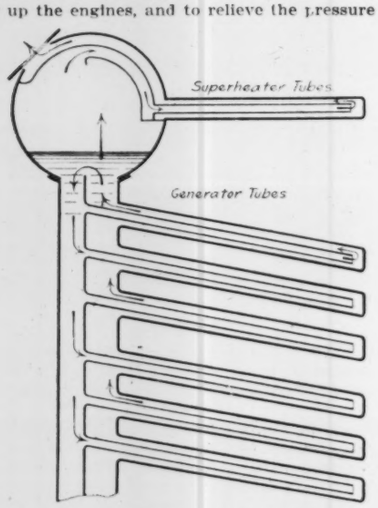


Fig. 8. The Durr Water-Tube Boiler.

BOILERS.

The boiler plant of the exhibition is contained in a separate building, near the Machinery Building, and comprises 52 boilers by various makers (including five foreign makers), and aggregating 20,400 HP. All of them are of the water-tube type, the majority having large tubes slightly inclined from the horizontal. The Climax and Conti boilers, however, have tubes of small diameter. Most of the foreign boilers are of types designed particularly for marine work. At the Columbian Exhibition at Chicago, in 1893, there were also 52 boilers, all of the water-tube type, and aggregating 20,575 HP.; the largest unit was a Climax boiler of 1,000 HP. While the nominal rating of the St. Louis plant is about the same as that of the Chicago plant, it is expected that the boilers will be run continuously at 25 to 50% above their rating. The guaranteed evaporating capacity of these boilers at St. Louis is given as 776,500 lbs. of water per hour, and the list of boilers is given in the table below.

The Babcock & Wilcox boilers are of the familiar type, with longitudinal inclined tubes and headers (of wrought steel) connecting with overhead longitudinal drums. These boilers have the Roney stokers. The Cahall horizontal boilers are of the same general type, with cast steel inclined headers (at right angles to the tubes) for the high pressure, and cast-iron vertical headers for the lower pressure. One of these boilers, with the ash-pit arrangement, is shown in Fig. 7. These boilers have the Mansfield chain grates. The Cahall vertical boilers have 4-in. vertical tubes connecting upper and lower drums. The Heine boilers also belong to the same general class as the Babcock & Wilcox, and have the Green chain grates. The Climax boiler has a central vertical drum, from which extend horizontal horseshoe loops of small pipe, filling the annular space between the drum and the casing.

The Durr and Niclausse boilers have tubes nearly horizontal, And closed at the rear end. In each tube is a smaller circulating tube, and the header is divided into two sections, the small tubes opening into the front section and the large tubes into the rear section. Both sections connect with a transverse drum. The system of construction is shown by the diagram of the Durr boiler in Fig. 8. Horizontal staybolts pass across the header, in the spaces between the tubes. This boiler, which works under natural draft, has a superheater consisting of a series of horizontal tubes, similar to the generating tubes, which projects from the steam drum. The boiler has 2,282 sq. ft. of heating surface, and 1293 sq. ft. of superheating surface, with a grate area of 54.7 sq. ft. The steam space has a capacity of 70.6 cu. ft. The weight of boiler complete, but empty, and exclusive of smokestack, is 21.2 tons, and the weight of water in working order is about 4.7 tons. In the Niclausse boiler no staybolts are used, the larger tubes extending through to the boiler front, where they are closed by screw caps, while openings pierced in them afford communication with both parts of the header. This is shown in Fig. 9. The headers are of wrought steel, made in sections, each wide enough for two rows of tubes, and extending the full height. The boilers at St. Louis have ten headers, each with 30 steel tubes, 3 ins. diameter and 8 ft. long. They have 2,085 sq. ft. of heating surface and 50 sq. ft. of grate area. The Belleville boiler has flat circulating coils formed of slightly inclined pipes (inclined alternately in opposite directions) connected by elbows. Each coil or element is continuous and independent from the feed drum below to the steam drum above. Vertical pipes form the return connection to the feed drum. A forced feed system is required. The Conti boiler has small tubes, both horizontal and vertical, the latter being curved; they connect with longitudinal and transverse drums.

All the American boilers, with two exceptions, are fitted with mechanical stokers; and nearly all the boilers work under mechanical draft. It was hoped that there would be very little smoke, but, as a matter of fact, the smoke is at times objectionable. The coal and ash-handling plant has already been described.

The mechanical draft for the 16 Babcock & Wilcox boilers of the Westinghouse service plant has also been described, but the draft apparatus for the other boilers has been installed by the Buffalo Forge Co. In view of the fact that the boilers will be run at considerably above their rated power, the necessary intensity of draft will be secured by running the fans at speeds which are unusual for such large sizes, and where possible duplicate fans are installed. Each fan is directly connected to a horizontal engine with piston valves, and the fan housing is dished to allow of placing a water-cooled self-oiling bearing close to the center of gravity of the wheel. The fans discharge into steel smokestacks about 50 ft. high.

The eight Heine boilers (working at 4,000 HP.) are served by a duplicate equipment, each having a 240-in. fan housing, with 14-ft. blast wheel 5½ ft. wide, driven by a center-crank engine with cylinders 14 x 14 ins. One of these is shown in Fig. 10. The maximum speed is about 143 revolutions per minute, and in order to run economically under high variations of load, the eccentric is controlled by a link motion adjustable while the engine is running. The throttling governors vary the speed, and in order to secure any desired draft pressure, the governor mechanism may be adjusted for the desired speed and the link motion set for the earliest possible cut-off. A similar equipment serves one group of Cahall boilers. Each of the two other groups of Cahall boilers is served by a 210-in. fan housing with a blast

Boiler Plant of the St. Louis Exhibition.

Maker.	Type.	No.	H.P.	Total H.P.	Pressure lbs.
Babcock & Wilcox, New York	Babcock & Wilcox, horiz.	16	400	6,400	200
Aultman & Taylor Machinery Co., Mansfield, O.	Cahall, horiz.	8	500	4,000	225
" " " "	" "	8	400	3,200	175
" " " "	Cahall, vert.	3	250	750	175
Heine Safety Boiler Co., St. Louis, Mo.	Heine, horiz.	8	400	3,200	175
Clonbrock Steam Boiler Co., Brooklyn, N. Y.	Climax, vert.	2	300 and 250	550	....
Dusseldorf-Ratinger Rohrenkessel Fabrik: Dusseldorf, Germany	Durr, horiz.	1	500	500	190
Societe Delaunay-Belleville, St. Denis, France	Belleville, horiz.	3	500	1,500	300
J. & A. Niclausse, Paris, France	Niclausse, horiz.	2	400	800	215
Schuette-Kessel-Konsortium, Geestemunde, Germany	Conti.	1	500	400	....
Totals		52	....	20,400	....

wheel 12 ft. 4 ins. diameter and 3 ft. 7 ins. wide, driven by an engine with cylinder 12 × 12 ins., running at 220 revolutions. The Belleville and Niclausse boilers form a group which is served by a duplicate plant, each portion of which has a fan designed for 2,550 HP., and running at 175 revolutions; these fans have blast wheels 12 ft. 4 ins. diameter and 4 ft. wide, driven by engines 12 × 14 ins.

The boiler house also contains two gas producer plants; one of these is by R. D. Wood & Co., of Philadelphia, having a capacity of 350 HP. and designed for either anthracite or bituminous coal; the other is by the Weber Gas & Gasoline Engine Co., of Kansas City, and supplies the Weber gas engine. In addition, there is a plant

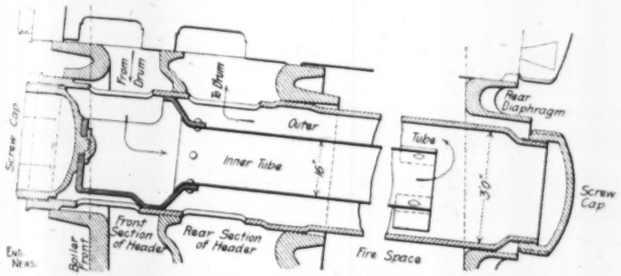


FIG. 9. TUBES OF THE NICLAUSSE WATER-TUBE BOILER.

for the manufacture of coal briquettes, with a capacity of 10 tons per day; this is installed by Wm. Johnson & Son, of Leeds, England.

AUTOMATIC LUBRICATING SYSTEM.

One of the features of the power plant is the automatic oil feeding and filtering plant, which is said to be the largest in the world, having a capacity of 2,000 gallons per hour. The plant consists of a separator 66 × 72 ins., a battery of six purifiers, four automatically governed duplex oil pumps, an air cushion pressure tank, automatic by-passes, regulating valves, gages, etc. The separator receives the dirty waste oil and water through pipes direct from 20 engines and other machinery; the oil is separated and the water automatically discharged into the sewer. The separator is located in a pit about 15 ft. deep to economize space. The oil is pumped by two duplex pumps from the separator into the purifiers, which are 66 x 60 ins., and have steam jackets. The oil is passed through two fine mesh strainers, and then enters the purifying chambers, where it receives a mild temperature treatment by the jackets, so that the impurities are readily

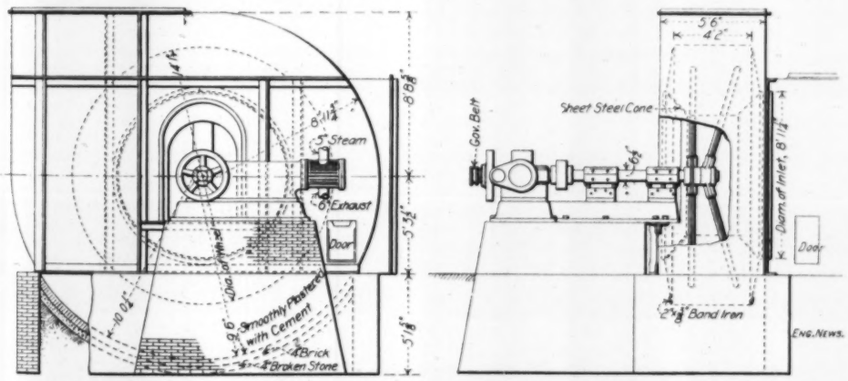


FIG. 10. FAN FOR INDUCED DRAFT PLANT AT THE BOILER HOUSE OF THE ST. LOUIS EXHIBITION.
Buffalo Forge Co., Buffalo, N. Y.

released and precipitated, while the oil is passing upward through this chamber. It then passes through three filtering cylinders into a clean oil reservoir, from which it is pumped into the oiling system. This automatic oiling system insures a constant pressure at every oil feeder, regardless of all variations in the quantity of oil which the system may be called upon to supply (from 1 gallon to 2,000 gallons per hour). The oil is drawn from the purifiers by two automatically governed duplex oil pumps, and then discharged into an air-cushioned oil reservoir. These pumps are also fitted with air valves for supplying the reservoir with air whenever needed. While in operation these pumps are set to run at about 25% greater speed than necessary, and this 25% of excess oil is constantly by-passing from the discharge chamber back into the suction chamber, through an automatic valve. In this manner any sudden and abnormal variations and demands in the supply of oil are promptly met by the air-cushioned reservoir, the by-pass valve and also the pump governor. Each pump is large enough to supply the system, and can be operated independently of the other. This plant was installed by the Famous Filter Co., of St. Louis, Mo.

ELECTRICAL DISTRIBUTION.

From a paper read before the Western Society of Engineers by Mr. E. B. Ellicott, City Electrician of Chicago (and until recently Chief Electrical and Mechanical Engineer of the Exhibition), we take the following notes:

Eight units, aggregating 16,000 KW., generate three-phase 25-cycle alternating current at a potential of 6,600 volts, and these are used for the general lighting and power requirements. For arc lighting inside the buildings and in the outlying sections there are five units of 2,580 KW., generating 50-cycle alternating current; these units include one of single-phase, two of two-phase and two of three-phase. The intramural railway power plant has six units of 3,000 KW., generating 550-volt direct current. The only other direct current units are those driven by the American engine (125 KW., 125 volts), and the Greenwald engine (400 KW., 250 volts). For exciter units there are three Westinghouse generators, 125 KW.; a Bullock generator, 200 KW., and a small turbo-generator set for the General Electric Co.'s steam turbine and generator. Other generators are excited by direct-current exciter, or by motor-driven sets.

From the main switchboard 17 three-phase lead-covered cables are run in a subway to points where they branch off into conduits to the respective buildings or sections of the grounds which each cable is to supply. There are three divisions of service required: 1, commercial lighting of the exhibits in buildings, the Pike and in the State buildings; 2, decorative lighting of buildings and grounds; 3, motors for cascade pumps and motor generator sets.

As a rule, the circuits are all operated from one set of bus-bars, with the exception of the cascade motor circuits, which, on account of the great size of the motors, proved to be too much of a disturbance on the lines. Special provisions were made to operate these motors from generators temporarily assigned for the purpose. The motor generator and rotary converter sets are placed in different buildings and on the Pike for the purpose of furnishing direct current at different voltages to exhibitors for power purposes. Where possible, the direct current has been carried from one building to another in order to minimize the number of motor generators and the attendant complications.

THE PAVEMENTS OF TORONTO.*

ASPHALT PAVEMENTS.—There has been keen competition during the year in the construction of this class of pavement, owing to another firm of contractors tendering for California asphalt, and consequently the prices dropped considerably. Compared with maximum prices in 1901, the decrease represents about 30%.

The use of stone curbing on streets paved with asphalt has been abandoned in favor of a combined concrete curb and gutter, which gives a much better finish and is more satisfactory and economical.

BRICK PAVEMENTS.—There has been a considerable increase in the mileage of brick pavements constructed, and had the supply been equal to the demand, more pavements of this class would have been laid. The brick pavements are in a very good condition and would be more popular were it not for the noise.

CEDAR BLOCK PAVEMENTS.—The mileage of this class of pavement has decreased very much. No new cedar block pavements, upon gravel foundations, were constructed, but some of the old pavements were re-laid with cedar blocks.

TAR MACADAM ROADWAYS.—Tar macadam roadways have become very popular. During the year, eleven streets were paved with this material. The first pavement was laid in 1900, and so far appears to be wearing very well. Upon residential streets with light traffic they are a great improvement on the ordinary macadam. On Dupont St., where street railway tracks were laid, it was decided to construct a tar macadam roadway, and this is the only street that has not proved entirely satisfactory. In my opinion the contractor did not use sufficient care in mixing the material. He had not previously constructed a roadway with this class of material and had inexperienced hands and no mechanical mixing machinery. We now construct brick gutters with tar macadam roadways, which is a decided improvement.

Owing to the continued increase in the number of these roadways constructed I decided last year to separate this class of pavement from macadam roadways, so as to give it special notice. This year there has been another decided increase in the number, and while even yet we are more or less in the experimental stage as far as the permanency of the roadway is concerned, still the results achieved (with one exception) indicate that it is a great improvement on the ordinary macadam for residential streets with light traffic.

We have perhaps made a mistake in placing this class of pavement on streets with street car tracks, which are usually streets with a moderate degree of heavy traffic, even when in the residence sections of the city; but the one failure in the construction of this pavement is, in my opinion, due to structural defects rather than traffic, as the surface coat did not bind and pack as it should, the result being a large number of holes and pockets in which the tar and paving pitch mixtures showed no adhesiveness. The stone used was the very best for the purpose and the binding materials passed very good tests, so we were forced to either one or both of the following conclusions as the cause of the defects in the pavement: 1. The contractor had not previously constructed a tar macadam pavement, had inexperienced hands and no mechanical mixing machinery, the mixing being done on sheet-iron boards in the same manner as concrete. 2. The stone was heated around flue heaters and some parts of a batch would naturally be hotter than other parts, and the tar and paving-pitch mixture was heated in a large kettle. These were mixed on sheet iron boards by shoveling in heaps and turning, the result being that some stones being cooler than others would have more of the binding mixture adhere to them and would consequently pack together, while the rest would not have sufficient to form a bond and when cool would crumble under traffic, if the heated state of the stone did not entirely burn the "life" out of the binding mixture and destroy its value altogether.

My own opinion is that the stone should only be dried so as to permit as much of the mixture as possible to adhere to it, for the stone when heated permits only a thin coating to adhere.

Other pavements constructed where this method has been followed have resulted in good pavements. From many engineering and sanitary view-points this pavement is much superior to ordinary macadam and should have a much longer wearing existence when constructed with proper materials and care.

One tar macadam pavement was constructed in 1900, one in 1901, six in 1902, and eleven in 1903. The length of tar macadam roadways constructed during the year totals 2.148 miles compared with 0.867 miles in 1902 and 0.054 miles in 1901.

CONCRETE PAVEMENTS.—Two such pavements have been constructed during the year, one on Francis St., on

*Abstracted from the last Annual Report of Mr. C. H. Rust, City Engineer of Toronto.

which there is considerable heavy traffic, and the other on McFarren's Lane.

This pavement as constructed by us consists of a 4-in. concrete foundation, similar to that used in constructing asphalt or brick pavements, with a wearing surface of 2½ ins. of concrete composed of one part of cement, one part of sand and three parts of fairly coarse crushed granite. These two courses are carried on together, as in constructing sidewalks, so as to secure a perfect bond between them. The surface is finished by "floating" with wooden "floats," and then a deep groove is used to cut the surface into blocks 5 × 10 ins. to give a better foothold for horses, about 15 ins. along the curbs being left smooth to provide free drainage for surface water. The pavement is cut into sections of about 20 ft. in length, with a ¾-in. joint of paving pitch, to provide for expansion and contraction and to prevent cracking or heaving, the pitch joint being also used along each curb, which on a pavement 20 ft. in width cuts the paved portion into separate blocks 20 ft. square.

It seems to make a very satisfactory pavement and its use could safely be extended on short streets and lanes. Besides being durable it is easily cleaned and very satisfactory from a sanitary standpoint. It is cheaper than brick or asphalt, and when laid with a view to prevent cracking, should be equally as durable as either of the above.

THE 40-TON GUY DERRICKS AT THE NEW WANAMAKER STORE, PHILADELPHIA, PA.

In erecting the steelwork for the new Wanamaker store being constructed at Philadelphia, Pa., the contractors were confronted with the problem of handling a large number of 20-ton columns and 13-ton plate girders in single pieces. To meet this problem special derricks were designed by the contractors, the Thomson-Starrett Co., of New York City, and built by Messrs. J. Jacob Shannon & Co., of Philadelphia, Pa. Three of these special derricks were constructed each of 40 tons capacity, and their success has been so great that a description of some of their special details is of interest.

In general the derricks have 75-ft. masts made of a single timber 24 ins. in diameter at the base and 20 ins. in diameter at the top. The booms are 65 ft. long. The guy ropes are 1¼ in. galvanized iron, and the hoisting ropes are ⅝ in. plough steel, made by the John A. Roebling Sons Co., of Trenton, N. J., and furnished by their agents, J. Jacob Shannon & Co., Philadelphia. The special details are the mast-head castings and the foot blocks. These are open hearth and steel castings.

The mast-head casting is shown by the drawings of Fig. 1. It consists of a socket slipping over the top of the mast, and made in two parts, which are clamped together by bolts. The socket carries the gudgeon pin, over which is slipped the spider casting, with a ring of rollers between. A cast plate secured by cotters holds the spider down on the gudgeon pin, and a sheet of brass is inserted in the shoulder bearing between spider casting and socket casting. The socket casting is secured by a "V" Bolt through the top of the mast. Other details and dimensions are shown by the drawings. It will be seen that the socket casting takes advantage of the full size of the timber at the top of the mast, and reduces the danger of shear.

The details of the foot block are shown by Fig. 2. In general it is the regular pin and socket arrangement, with the difference that both the thrust and side bearings are roller bearings. The details of this feature are clearly indicated by the drawings. Another point to be noted is the socket arrangement for receiving the foot of the boom. The use of roller bearings in the foot block and mast-head casting has resulted in making these 40-ton derricks as easy to swing as are many derricks of a fraction of their capacity.

We are indebted to the Thomson-Starrett Co. and to J. Jacob Shannon & Co. for the drawings and information from which this description has been prepared.

THE OUTLOOK FOR ENGINEERING EDUCATION.*

By C. Frank Allen,† M. Am. Soc. C. E.

Organized, as we are, to study problems of engineering education, it is proper for us to inquire what is to be in the future the special nature of the demand for men educated in engineering; and what we must do to meet the demand successfully.

It can be assumed without question that in the future as in the recent past, for positions directly in engineering, the graduate of the engineering college will in general be demanded, and that even more than in the past the positions of prominence, the prizes in the engineering field will mainly go to the school-trained men, and an untrained man will have little place in engineering. Recently the demand for engineering graduates has been sufficient to absorb the whole output from the colleges of engineering. A year ago the evident demand was perhaps double the apparent supply. During the year past [illegible] appeared to abruptly drop, but there has been [illegible] revival; to-day it may be, temporarily at least, [illegible] inferior to the supply.

Employment in engineering has generally [illegible] always proved the goal for the graduate. In many [illegible] it has rather been the channel, the period of preparation or probation for duties of a somewhat different character. In an increasing degree it has been found advantageous and desirable to secure superintendents, managers, [illegible] of railroads and other semi-engineering enterprises [illegible] motions from among the school-trained engineers. The policy of that splendid railroad system, the Penn[illegible], has long since been established; the civil engineer engaged upon maintenance of way finds himself [illegible] line of the office of Division Superintendent, to [illegible] in turn the office of General Manager or even of [illegible] is in line and an evident possibility. A large number of mechanical engineering graduates are now entering upon railroad work; indeed, in many instances in the past they have been selected to occupy the highest operating positions; there seems no reason why the prizes in future should not be fairly or evenly divided between the mechanical and civil engineers, while the rapidly increasing importance of electrical propulsion, and of electricity in signal work and otherwise will shortly demand a knowledge of electricity which will give to the electrical engineer an importance in general railroad work sufficient to introduce a new element of competition which the civil and mechanical graduates must face. To my notion, a legitimate field for engineers is the occupation of all executive positions where engineering knowledge and skill are of immediate value, although the work is not immediately and directly the practice of engineering. I hope and expect to see this field constantly enlarging for the engineer and I desire that the engineer shall consider that the dignity of the profession does not suffer by his acceptance of such posts of honor and usefulness.

Another field open to men trained as engineers is that of contract work in engineering construction. To some this has seemed, in civil engineering at least, as a lowering of dignity. A somewhat broader view appears to be that methods of executing work are often more important as features of engineering than is the ultimate design. Furthermore, if the school-trained engineer-contractor does bring to his work greater skill in execution, greater pride in honesty of construction, and a better analytical understanding of the cost of various elements of the work, with diminution of the risk, and a consequent lowering of the cost (as I believe he does) then the contractor is not and ought not to be, as sometimes in the past, in any sense a constitutional foe of the engineer in charge, but rather a help, or better, an engineer legitimately in the practice of a special branch of engineering which ought properly to attract those whose abilities and tastes lead them towards it. In bridge work, machine shops, electrical manufacturing and installation, and many kinds of engineering it

*Extracts from the presidential address before the Society for the promotion of Engineering Education at its Annual Convention in St. Louis.

†Professor of Railroad Engineering, Mass. Inst. of Technology.

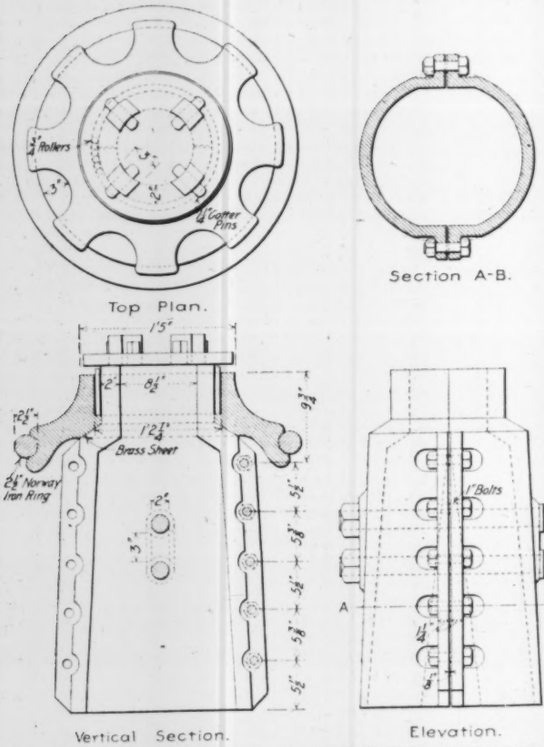


FIG. 1. DETAILS OF MAST HEAD CASTING FOR 40-TON GUY DERRICK.

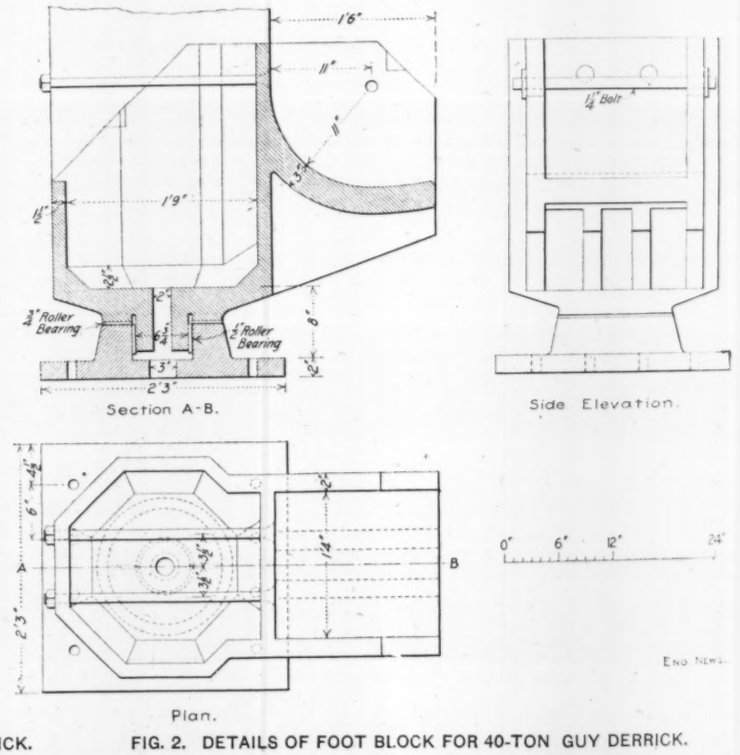


FIG. 2. DETAILS OF FOOT BLOCK FOR 40-TON GUY DERRICK.

has long been true that the standing of the contractor has been inferior on the whole to no other class of engineers.

New fields for men trained as engineers are opening daily. Looking backward for 35 years, it appears to be true that the opportunity for employment for the large numbers graduated now, is definitely better than for the limited numbers of graduates at that early time. It is my judgment that the demand for engineers that comes from the development of engineering enterprises is due in very considerable part to the fact that there has been available in increasing quantities, a supply of competent engineers, and this in turn to the fact that in this country the opportunities for engineering education have been more general and its quality better than in the earlier days.

In many instances individuals have largely or entirely created their own opportunities, and have often incidentally enlarged the general field of engineering opportunity and employment, so that the increased general demand has in many instances been due specially to the superior quality of the supply as shown by some individual engineer. The city engineer of a small city in Massachusetts failed to secure re-appointment when a change of administration was made. He had given careful study to road construction, which was then receiving much attention, and at some apparent sacrifice at first, he continued to give special attention to this class of work, in which he attained acknowledged prominence. His influence was important in securing the appointment of the Massachusetts Highway Commission (of which he has always been the most active member, and is now chairman) which has constructed about 575 miles of State Highways; with an expenditure by the commission of more than $4,500,000, besides aiding largely in the impetus given to highway construction the country over. The engineer largely created his own opportunity—the supply created the demand in his case.

Two of the most important engineering projects in Massachusetts, the Metropolitan Water Supply and the Charles River Basin, are the results of careful work and able reports by an engineer who was recognized as an able investigator, but who appeared to be shelved from active construction in his position of chief engineer of the State Board of Health. The expenditure upon these two projects will be about $28,000,000 and the engineer in question is either chief or consulting engineer of both schemes. The general opening of opportunities for many other engineers which has been created by these works has been of great importance to engineering. Instances of the man creating his opportunities could be multiplied indefinitely.

The field chosen by the individual for his opportunity is not always pure engineering. While the demand for engineering and the demand from engineering enterprises the demand for engineering graduates, the demand for engineering education is strongly on the increase, yet the day of trouble is before us, the day of financial crisis, when enterprises languish, when the demand falls sharply off, and the supply continues, although in diminished numbers. Then will come the time when the practicing engineer and the engineering graduate will find a necessity, not now existing largely, to make for himself his opportunity which will lie outside the established lines of engineering; when he must accept not what he would but what may be offered, and the engineering graduate will be forced into general business, into manufacturing. It seems reasonable that his greatest usefulness will first be found with dealers in engineering or mechanical supplies, or in manufacturing where engineering skill can never be amiss; already the demand in these directions has become a reality, rather than a possibility. Already some of the manufacturers' insurance companies employ a large force of men trained in engineering. Life, fire and marine insurance constitute, likewise, reasonable fields. Banking, and the sale of stocks and bonds, are occupations to which in many instances engineering graduates have already found themselves adapted by the training they have received and in which the line of study followed in the engineering college has been found frequently to be of practical advantage.

For the purposes of general business of various classes, if more than the high school course is to be attempted, what is there better for preparation than what a young man receives in our engineering colleges, as the courses are now arranged? There is recently much unanimity of feeling among our foremost educators that education should have as its object "training for power" as the expression is. Nothing in education is more important than that the student should be forced to think. The man who has experienced religion in a twinkling has no more surely caught a glimpse of a new world and a new life than the dull student who finally exclaimed to me, his tutor in a mathematical subject, "I see, you want me to use my good sense, and not my memory." He had seen the light; he was a dull student no longer, nor was I longer his tutor. Isn't it true that the old classical courses in our colleges, with history and language predominant, tend to train the memory far beyond all else; and that the engineering courses, with mathematics and science predominant, tend to compel thought? Do the academic courses in our colleges differ sufficiently from the classical courses in this feature to be free from the same criticism? A man becomes strong by virtue of the work he does, the exercise he takes; one measure, often a good one, of the efficiency of instruction, is the amount of work demanded from the student; a good measure of bad teaching is the amount of work assumed by the teacher which should fall upon the scholar. Without taking the above propositions literally, it is well known to those familiar with the facts, that the student in the engineering course cheerfully works much harder than his neighbor in the same college who has selected the academic course. Which student is securing the greater strength?

The study of mathematics in lines advanced beyond the high school scope must certainly be of value to the man who desires to have a grasp in matters of accounting and finance. The study of science trains him to observe facts and phenomena and to draw correct inference and conclusions from such facts; business procedure, also, should be founded on a knowledge of underlying facts, and the successful business man should be he who successfully interprets these facts.

To my mind it is also true that the information acquired in the engineering course is likely to prove of value to the business man, although we all understand that this is not the important feature of the education. A knowledge of chemistry, of physics, of the properties and laws which determine the behavior of materials, a proper understanding of the nature and laws applying to the use of steam, electricity and water wheels, or in other words an understanding of power and its use; these at least constitute a resource for understanding and handling things material and mechanical, which ought to be of value to any business man, and especially to those whose business has intimate connection in any way with manufacturing. To the scientific studies are added, at least in very many of our engineering colleges, courses in history and economics, some familiarity with French and German, and in reasonable amount the study of clear expression in English. Isn't it true that this training is strong in securing habits of application, strong in training the proper qualities of the mind, strong in the useful knowledge of facts and principles acquired?

But beyond all this is the moral training, the training in character which is a natural result of an intimate acquaintance with science, of close contact with scientific methods and reasoning. The study of science is, it must be, the search for truth, and it must from usage cultivate a love for truth. That the scientific attitude of mind is of supreme importance as an element of character building seems to me on principle to admit of no doubt. As a matter of observation, I know of no class of men whom I believe to be less subject to business corruption than the civil engineers who have come more especially under my notice, and I do not doubt that the school-trained mechanical, electrical and mining engineers are men of equally high character.

The influence of training in mathematics and science is also calculated, it seems to me, to develop another important element of character. The student learns in mathematics that correct procedure will secure correct results; in science correct observation and proper reasoning again will secure correct results. A clear appreciation of these truths naturally leads to the establishment of that quality of character which we call courage. An engineer unless he is trained so as to have acquired something of courage is comparatively valueless. A very able editor in the engineering field once stated that an important value of engineering education is that it enables one to look a fact in the face. It sometimes takes courage to do that. To me it seems most important that any business man should have learned courageously to look facts in the face; if the facts show not only present but also future losses as the result of continuance of a given policy or even of a given enterprise, the sooner the truth is known the better. Not all business men are proof against self-deception.

There remains untouched the question of executive ability, about which there seems to be much confusion of mind. That the engineering graduate by virtue of his years of study has had his executive capacity impaired, I am unwilling to believe. The numerous successful executives who have come from this class is an assurance otherwise. To the contrary it has always seemed to me that executive ability consists in important part in a knowledge and appreciation by any one of the things to be done, by others to be sure, under him. If a man by virtue of his education does have a proper appreciation of the behavior of materials, of the nature and use of power, of natural law, to my mind one of the requisites for executive ability has been largely secured.

From another point of view, it has seemed to me that the man educated as an engineer must have acquired, to be successful, the habit of investigating conditions and materials, and of devising methods of construction or operation dependent upon these conditions and materials. To the man trained in this way, the study of materials then becomes in part the study of men—the men with whom he has to deal or the men upon whom he depends, and his training has done much to secure a second qualification for executive ability.

That the great places are filled by men of inborn executive genius is no doubt true, but the geniuses are few and the positions are many, and these positions must be filled by men in whom, of course, the executive quality must not be definitely lacking, but men of good parts whose training and experience qualify them otherwise to successfully fill them, and I believe that this means the men with the engineering training in which science and mathematics play a leading part. That the ordinary academic college training will generally serve the same purpose I see no reason to believe.

In my judgment, not only is it true that graduates of engineering courses will find it necessary to enter into the field of general business, but I believe that their success will be sufficient so that this necessity will be most fortunate for the cause of what we are all interested in as engineering education. With the increased activity which will follow, broader fields will open out, and other important outlets for our graduates will be recognized and accepted. In the Boston public schools, college graduates only are eligible to the desirable positions for men. These men are now mostly graduates from the academic courses and as a rule highly trained in the classics rather than in science and mathematics. Large numbers of young men enter college well knowing that their first employment after graduation must be in teaching; many never leave this field. At present very few of the graduates of an engineering college are content to teach, unless in professional subjects in technical colleges and comparatively few, even then. When the time of stress arrives, teaching, as well as general business, will prove attractive and engineering education will reap a benefit from having the work of preparation in the hands of teachers interested in engineering, and trained most effectively in science and mathematics. The "Head Master" of a grammar school or the "Master" of a high school in some of our large cities receives a salary not inferior to that received by the majority of the faculty of most of our colleges, academic or engineering; the position is practically permanent, the opportunity for usefulness great, and the dignity sufficient so that many of our graduates might well look to teaching, provided their tastes and capacities indicated that as a proper vocation.

With the growing importance in the world of matters engineering and mechanical, there must also be a demand, constantly increasing, for journalistic work, not only for technical periodicals, but for newspapers and general publications. Not only on the side of an appreciation of the technical or engineering application of many matters of interest to the public, but also upon the literary side, there is no reason why engineering graduates should be at a disadvantage. If the engineering training tends to clear thinking, as we believe it does, it ought also to tend to clear writing. A clear view of an idea to be expressed is the first requisite to clear expression. The engineering training tends strongly to secure not only clearness, but it seems to me simplicity of style, and if these be secured, little else need be desired.

If the field of employment for graduates in engineering is to be in effect what has been set forth above, what shall be the character of the college of engineering in the future? For the present, at least, the college of engineering as now commonly organized for undergraduate work seems to be very efficient and to reasonably meet the demands and requirements of the engineering profession. Will it continue to do undergraduate work or will it become peculiarly a professional school, and open only to graduates of colleges (academic or engineering) at that? In my view, the great demand will be permanently for the engineering college doing undergraduate work; whether as a preparation for engineering proper, for semi-engineering or non-engineering executives in the conduct of large enterprises, for positions in general business life, or for the work of teaching. That there will be a moderate (but perhaps a limited) demand for engineers trained well beyond what is possible in a four-year undergraduate course, is to me a proposition whose truth cannot be questioned, but that the great body of engineering graduates should be as highly trained admits of serious doubt.

Whenever the demands of engineering require men trained farther and higher for the more important positions, how shall the work be done? In purely professional schools open only to college graduates? Possibly, but if so, for the best development, then the graduates must be men well trained in science and mathematics—trained very much as we now train the men in our undergraduate engineering courses. The logical outcome appears to be, not the professional engineering school or college, but rather a development of graduate work, the granting of the advanced degree, with the advantage not only of building upon a foundation sound and sure, but also of attracting and developing mainly those men whose demonstrated ability shall have established a probability of worthiness sufficient to secure the advanced degree, the survival of the fittest. Not only does this seem the logical development, but in this country also it is the actual development and it is taking place in several of the foremost schools of engineering.

That the undergraduate engineering courses in our colleges are destined soon to outstrip in numbers the academic, I do not entertain a doubt. Indications are not lacking that, taking the country as a whole, that result may have been already accomplished. That the engineering courses furnish a superior training is my firm conviction. The field is or is to be ours and with it increasing responsibilities, increasing dangers, against which we must guard.

TESTS OF AN OIL ENGINE WITH STEAM INJECTION.

An oil engine of unusual type has been placed on the market recently by Mietz & Weiss, of 128-138 Mott St., New York City. A 15-HP. engine of this type has been tested for oil-consumption by Messrs. Charles Wineburgh and S. J. Goldwater, who reported the results in a Mechanical Engineer's thesis submitted to Cornell University in the academic year just closed. An abstract of these results is given below.

As appears from Fig. 1 and the preceding explanation, there are no valves or other moving auxiliary parts except the fuel pump P. The governing of the engine is performed by a shaft governor, which acts to shift the eccentric that drives the fuel pump. By thus changing the stroke of the pump, the governor varies the oil supply. As the results given farther on indicate, the speed is very uniform at different loads.

The engine in general is closely similar to the style of Mietz & Weiss kerosene engine hitherto built. The new feature is the use in the cylinder of steam generated in the water space. It happens that attempts at a somewhat related object were made years ago. Lenoir, in France, patented a gas-engine in 1861 wherein he proposed to "inject a little steam or water spray into the cylinder at the same time that the air and gas enter." The same idea was entertained by the French engineer Hugon at about the same time. The purpose was to let the water-spray do the work of the cylinder-jacket in cooling the cylinder, and at the same time have the cooling action reach the piston more effectively, piston design in those days being less perfectly understood. But other makers showed that gas engines could be made to run without the complication entailed by the water spray, and the latter was soon dropped. Ten years later an engine for the Brayton constant-pressure type was built in England which contained an evaporating attachment for utilizing some of the waste heat to produce steam to be used in the cylinder. Here again the complication of the device and the absence of beneficial results caused its abandonment.

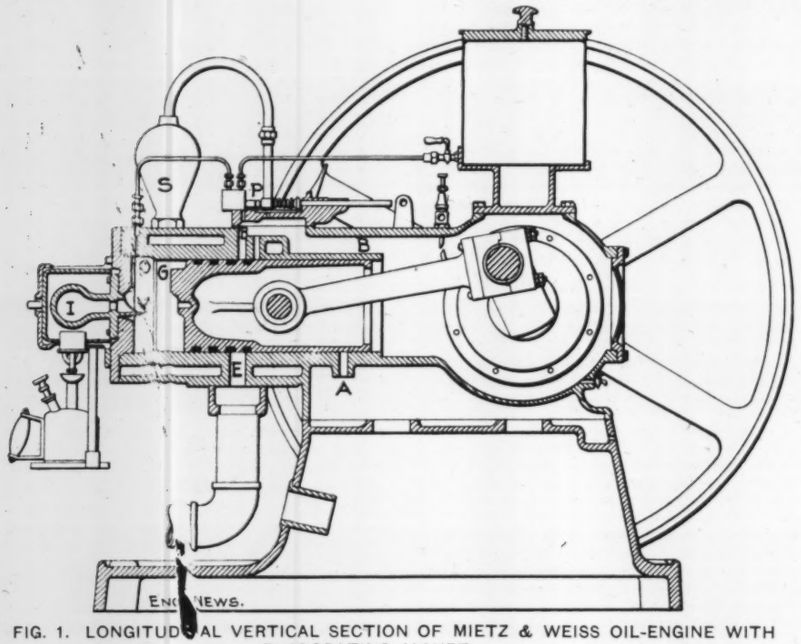


FIG. 1. LONGITUDINAL VERTICAL SECTION OF MIETZ & WEISS OIL-ENGINE WITH EVAPORATING JACKET.

The unusual feature of the engine is that the heat imparted to the water in the cylinder jacket is allowed to vaporize the water, and the steam produced is passed into the cylinder at the same time as the oil and air.

The engine is shown in vertical longitudinal section in the accompanying Fig. 1. The fuel oil is stored in a tank mounted on the crank-case. A small pump P feeds it through a port O into the cylinder, where it falls on the projection V of the igniter I. The latter is a casting shaped like a hollow sphere, and is heated by means of a gas or oil flame before starting the engine; during the operation of the engine it is kept hot enough to ignite the successive charges without additional heating. The inward projection V, which is also at high temperature, vaporizes the oil. Air is drawn into the crank-case, during the compression-stroke, through the port A, is compressed during the working stroke, and then passes through the port B into the cylinder. The guide projection G on

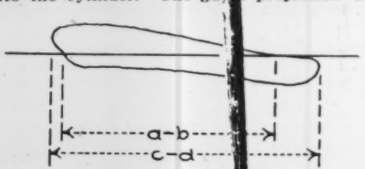


Fig. 2. Method of Finding Volume of Air Used, from Crank-Case Card.

the back of the piston deflects the entering current of air away from the exhaust-port E which is open at the same time as the air-port B. The cylinder-jacket communicates with a sort of steam-dome S, from where a pipe leads to the air-passage from the crank-case to the cylinder. Thus any steam generated in the jacket passes into the cylinder with the charge of air. By means of a device similar to a steam-trap, the water in the cylinder-jacket is maintained at a constant level, regardless of the temperature of the cylinder. Thus, there is no circulation as usually found, but only as much water is supplied to the jacket as is needed to make up the loss by evaporation.

The Weiss arrangement, using steam evaporated directly in the cylinder jacket, is not only evidently different from these in principle and method, but it also introduces no additional parts, comprising merely a small steam dome, a short steam-pipe, and a float-controlled valve for keeping the water at a constant level in the jacket. This valve takes the place of the circulating pump required in the ordinary engine, and is even simpler than the latter.

The Weiss arrangement has the threefold effect of 1, utilizing a large part of the heat ordinarily lost through the cylinder walls; 2, considerably reducing the trouble from deposition of carbon in the cylinder (probably by the dissociation of the water vapor furnishing oxygen to the hot particles of carbon), and 3, maintaining a considerable difference of temperature between piston and rear wall of cylinder. The latter effect is produced by the location of the water feed pipe, which, in connection with the slow movement of water in the jacket, keeps the piston end relatively cool while allowing the water to evaporate at the hot end.

The engine shows a high efficiency on test, a very regular action, and an unusual freedom from soot deposits; no disadvantageous features of the steam device have been observed. The author of the thesis above referred to makes the following remarks bearing on regularity:

> The engine ran very smoothly throughout the test. On several occasions it was kept in continuous operation for ten hours while the load was varied a number of times during that period, but it required no attention except the occasional refilling of the water-tank and of the lubricating and fuel oil reservoirs.

And in their conclusions they say:

> . . . there is no necessity of a cumbrous water-tank nor of constant adjustment of the water supply, no waste of water on light loads nor yet any danger of the cylinder walls or piston becoming too hot on heavy load. And during the weeks of the test, with the engine running almost constantly, there was not once a shaft-pre-ignition, nor an explosion missed.

The Weiss steam arrangement is now incorporated in all the oil engines which Mietz & Weiss build. The largest to which it has yet been applied is of 60 HP. The operation is fully as satisfactory in these large sizes as in the 15-HP. engine tested.

The principal data and results of the tests made on this engine are summarized in the following:

> The test was conducted in the testing department of Mietz & Weiss, 128-138 Mott St., New York, during February, 1904. It was at first intended to make a comparative test of the engine with the ordinary jacketing system and with the system actually employed, i. e., evaporating the jacket water and feeding the steam into the cylinder. On account of the lack of time, however, and the necessity of refitting the piston if both tests were to be made, this scheme had to be abandoned and the test made as reported; but it is probable that the high thermal efficiencies

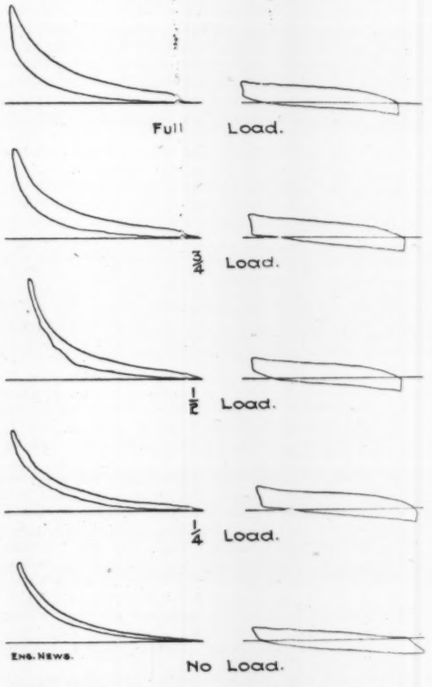


Fig. 3. Indicator Cards of 15-HP. Mietz & Weiss Oil-Engine with Evaporating Jacket, Taken During Brake Tests. (Half Original Size.)

FULL LOAD.—Scale of spring, 120 lbs.; area, 0.55 sq. in.; length, 2.34 ins.; M. E. P., 29.48 lbs. per sq. in.

¾-LOAD.—Scale of spring, 120 lbs.; area, 0.44 sq. in.; length, 2.36 ins.; M. E. P., 22.38 lbs. per sq. in.

½-LOAD.—Scale of spring, 120 lbs.; area, 0.33 sq. in.; length, 2.33 ins.; M. E. P., 16.99 lbs. per sq. in.

¼-LOAD.—Scale of spring, 120 lbs.; area, 0.26 sq. in.; length, 2.43 ins.; M. E. P., 12.84 lbs. per sq. in.

NO LOAD.—Scale of spring, 100 lbs.; area, 0.19 sq. in.; length, 2.38 ins.; M. E. P., 8.18 lbs. per sq. in. (corrected).

FULL LOAD.—Scale of spring, 120 lbs.; area, 0.51 sq. in.; length, 2.10 ins.; M. E. P., 2.43 lbs. per sq. in.

¾-LOAD.—Scale of spring, 10 lbs.; area, 0.57 sq. in.; length, 2.11 ins.; M. E. P., 2.70 lbs. per sq. in.

½-LOAD.—Scale of spring, 10 lbs.; area, 0.49 sq. in.; length, 2.05 ins.; M. E. P., 2.39 lbs. per sq. in.

¼-LOAD.—Scale of spring, 10 lbs.; area, 0.585 sq. in.; length, 2.18 ins.; M. E. P., 2.86 lbs. per sq. in.

NO LOAD.—Scale of spring, 10 lbs.; area, 0.515 sq. in.; length, 2.31 ins.; M. E. P., 2.44 lbs. per sq. in.

Brake Tests of 15 HP. Mietz & Weiss Kerosene Engine with Evaporating Jacket.

TABLE I.—Summary of Data and Results.

Number of run	6	7	8	9	10
Approximate load	Full load	¾ load	½ load	¼ load	No load
Duration of run, hours	2	2	2	2	1½
Oil, pints, total	32.01	27.11	20.26	17.44	9.06
" pints per hour	16.00	13.55	10.13	8.72	6.04
" lbs. per hour	13.20	11.18	8.35	7.19	4.98
Jacket-water, total, pints	79.48	65.55	52.69	40.56	12.55
" " lbs	82.82	68.35	54.94	42.30	13.08
" " lbs. per hour	41.41	34.17	27.47	21.15	8.72
Temperature, water entering	54.0	46.7	57.4	55.1	55.7
" equalizer, corrected	194.3	193.6	196.9	195.3	184.7
" jacket, corrected	198.3	196.5	195.0	190.8	178.8
" exhaust, corrected	539.0	501.4	467.5	425.0	366.7
" room	72.1	67.0	74.0	74.2	62.0
Revolutions per minute	283.5	289.2	290.3	297.2	309.0
Explosions per minute	283.5	289.2	290.3	297.2	309.0
Brake load, lbs., net	230.3	161.0	114.8	60.6	0.0
Air, cu. ft. per hour (actual)	5,944	6,803	7,179	7,656	7,524
" " " (standard conditions)	5,296	6,231	6,547	7,021	7,080
" lbs. per hour	427.4	502.0	528.0	569.0	571.3
Exhaust gases, lbs. per hour	440.6	513.2	536.3	576.2	576.3
Ratio air to oil, by weight	32.4	44.9	63.21	79.11	114.8
Specific heat of exhaust gases	.244	.243	.241	.240	.239
Maximum pressure, lbs. per sq. in. abs.	185	178	194	157	134
Compression pressure, lbs. per sq. in. abs.	114	109	109	102	80
M. E. P., power end	29.80	25.56	19.01	16.45	8.35
" crank-case end	2.35	2.50	2.40	2.47	2.23
" net	27.45	23.06	16.61	13.98	6.12
I. H. P., working end	20.10	17.58	13.13	11.63	6.14
" net	18.51	15.86	11.47	9.88	4.50
Brake HP	15.27	10.90	7.80	4.22	....
HP. lost (without loss by fluid friction	3.24	4.96	3.67	5.66	4.50
HP. lost (including loss by fluid friction	4.83	6.68	5.33	7.41	6.14
Efficiency, "A"	.832	.701	.684	.443	....
Efficiency, "B"	.765	.630	.597	.372	....
Oil consumption, in pints, per I. HP. per hour at power end	.796	.771	.771	.750	.983
Oil consumption, pints, per I. HP. per hour, net	.864	.855	.883	.883	1.342
Oil consumption, lbs. per I. HP. per hour, at power end	.656	.636	.636	.618	.811
Oil consumption, lbs. per I. HP. per hour, net	.713	.705	.728	.728	1.107
" " pints per D. HP. per hour	1.048	1.243	1.298	2.070	....
" " lbs. per D. HP. per hour	.864	1.026	1.071	1.704	....
B. T. U. per D. HP. per hour	16,000	19,000	19,840	31,560	....
Thermal efficiency from I. HP., power end	.209	.216	.216	.222	.169
" " from I. HP. net	.193	.195	.189	.189	.124
" " from D. HP.	.159	.133	.128	.081	....
Maximum thermal efficiency	.445	.445	.445	.445	.445

obtained may, at least in part, be ascribed to this improvement.

FUEL.

The fuel used was ordinary American kerosene oil. Analysis showed the composition to be:

Carbon, 84.98 parts.
Hydrogen, 15.02 parts, by weight.

From the tables (Moss's Notes on Gas Engines), we find:

Higher heating value of Hydrogen = 62,100 B. T. U. per lb.
Lower heating value of Hydrogen = 52,230 B. T. U. per lb.
Heating value of carbon (to CO_2) = 14,650 B. T. U. per lb.

The theoretical higher heating value is, then,
$(.8498 \times 14{,}650) + (.1502 \times 62{,}100) = 21{,}765$ B. T. U. per lb.

The theoretical lower heating value (if we neglect the heat of vaporization of kerosene, which is small), is
$(.8498 \times 14{,}650) + (.1502 \times 52{,}230) = 20{,}285$ B. T. U. per lb.

The difference between the two is 1,480 B. T. U. per lb.

However (owing, probably, to dissociation) the theoretical heating value is never realized, and the higher heating value of the oil found by means of the calorimeter is only 20,000 B. T. U. per lb. The lower heating value, which represents the heat available in the engine, is, therefore, 20,000 — 1,480 = 18,520 B. T. U. per lb.

TESTS.

Two series of runs were made, one with the engine coupled directly to a compound dynamo, and the other with the dynamo disconnected and a cylindrical drum bolted to the fly-wheel so that a brake could be applied. During the runs with the dynamo, the latter was used merely as a load, and no attempt was made to separate the losses in the dynamo from the mechanical losses in the engine. Each test consisted of five runs during which the load on the engine was varied from no load to the full rated load by approximately equal gradations. A short run was also made with the engine considerably overloaded, but as the duration of the run was only 20 min., the results are not included in this report because they might be considered unreliable.

In the first set of runs the power was consumed by a bank of 110-volt 16-c. p. incandescent lamps. Owing to the low resistance of the rheostat furnished with the dynamo, it was found impossible to use the lamps at the voltage for which they were intended, excepting at nearly full load even though the engine was run below its rated speed. During the second test, the governor was adjusted so as to give about the rated speed and the energy developed was consumed by a rope brake. This consisted merely of a heavy rope wrapped several times around the drum; at one end the rope was attached to a spring balance suspended from a beam, while at the other end it was allowed to hang with part of its weight supported by the drum and part by a stationary support.

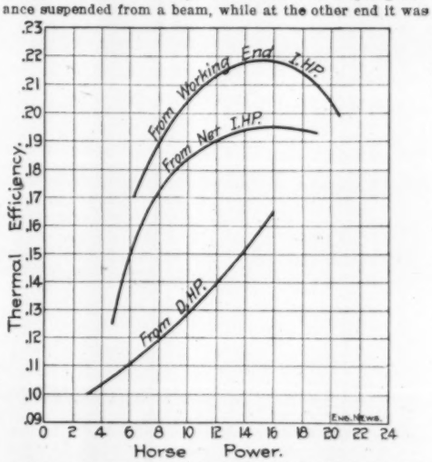
Two indicators were used; one was attached to the working cylinder, and the other to the crank case. The piping to the indicators was made very short so as to reduce the effect of throttling. The piping of the power-end indicator had no elbow, and that of the crank case indicator but one. The reducing motion consisted of a small crank fastened to one end of the crank shaft. To duplicate the effect of the angularity of the connecting rod, the crank, instead of moving the indicator directly, was used to oscillate a long rocker which was pivoted about 2 ft. below the center of the engine. The length of the cord from crank pin to rocker was made six times the throw of the small crank, as the connecting rod of the engine was six times as long as the crank.

It was found impossible to take the cards from both ends of the engine simultaneously, owing to the fact that only one end of the shaft could be used, and in the small space available it was impossible to arrange two rockers so that they could be used at once. As the crank cards, however, depend on such conditions alone as should remain constant during any run, it was thought sufficiently accurate to take a number of cards before and after each run, and, when convenient, during the run the operating conditions being kept the same.

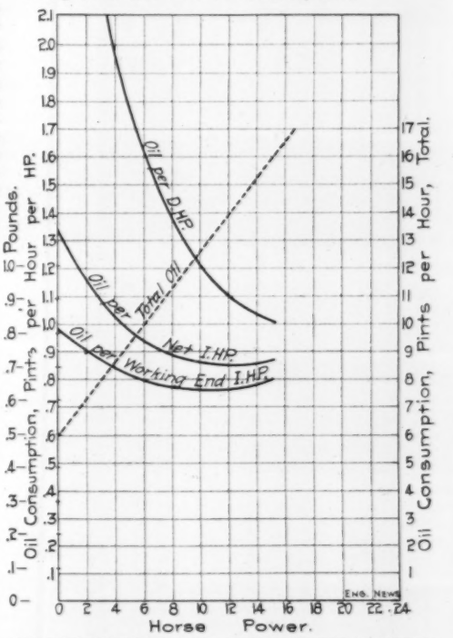
The oil and water were supplied from cylindrical tanks (15 ins. inside diameter) and the levels at the beginning and the end of each run noted by means of level gages. The results obtained by computation were checked by filling the tanks from the lower to the upper levels by means of standard liquid measures.

Revolutions per minute were obtained by means of an ordinary hand speed-counter.

The thermometers and indicator springs were calibrated before use. All temperatures excepting those of room and of entering water were observed at intervals of ten minutes, as were also the speed, the brake scale readings, and the amperes and volts. The temperature of the room and water remained nearly constant and were observed at less frequent intervals. Indicator cards were taken from the working end at ten-minute intervals. The method of taking crank case cards has been explained.



FIGS. 4 AND 5. THERMAL EFFICIENCY AND OIL-ENGINE WITH EVAPORATING JACKET. GOLDWATER, 1904.


Oil Consumption, Pints per HP. per Hour. Pounds.
Oil Consumption, Pints per Hour, Total.
Oil per D.HP.
Oil per Total Oil.
Net I.HP.
Oil per Working End I.HP.
Horse Power.
ENG. NEWS.

OIL-CONSUMPTION OF 15-HP. MIETZ & WEISS FROM TESTS OF C. WINEBURGH AND S. J.

Brake Tests of 15 HP. Mietz & Weiss Kerosene Engine with Evaporating Jacket.

TABLE II.—Distribution of Heat Supplied.

Number of run		6	7	8	9	10
		Full load	¾ load	½ load	¼ load	No load
Heat supplied per hour	B. T. U.	244,000	207,050	154,700	133,200	92,200
	per cent.	100	100	100	100	100
Heat equivalent of I. HP. working end	B. T. U.	47,100	44,700	33,400	29,600	15,620
	per cent.	20.9	21.6	21.6	22.2	16.9
Heat equivalent of I. HP. net	B. T. U.	47,100	40,360	29,200	25,140	11,450
	per cent.	19.3	19.5	18.9	18.9	12.4
Heat equivalent I. HP. crank case (loss by fluid friction)	B. T. T.	4,050	4,380	4,200	4,460	4,170
	per cent.	1.6	2.1	2.7	3.3	4.5
Heat absorbed by jacket water. Total.	B. T. U.	52,960	43,330	34,090	25,866	10,410
	per cent.	21.7	20.9	22.0	19.3	11.3
Heat absorbed by jacket water in jacket (max.)	B. T. U.	47,280	39,000	31,350	24,120	9,900
	per cent.	19.4	18.8	20.3	18.1	10.7
Heat absorbed by jacket water in cylinder	B. T. U.	5,680	4,330	2,740	1,746	510
	per cent.	2.3	2.1	1.7	1.3	.6
Heat lost in exhaust	B. T. U.	50,190	54,200	50,800	48,490	41,970
	per cent.	20.6	26.1	32.8	36.4	45.5
Radiation and other losses	B. T. U.	89,700	64,780	36,410	29,244	24,200
	per cent.	36.8	31.3	23.6	22.0	26.3

During the test samples of exhaust gas were collected while the engine was running at no load, half load and full load. These samples were analyzed, but as they were collected over water, which dissolves carbon dioxide, the results obtained were not very definite.

In reference to the methods of calculating the results from the observations, the following points are noted:

Explosions per minute.—Are equal to the revolutions per minute at all loads, since no explosions were missed.

Air.—No meter was available, and the amount used can be only approximately determined from the observed data. We know that the amount of air must have been more than sufficient for complete combustion, for analysis of the exhaust gas showed such combustion and indicated a considerable excess of air even at full load.

The air required theoretically for the combustion of a pound of the fuel used is 14.98 lbs., which gives, for the full load brake run (No. 6), only 198 lbs. of air per hour. The actual amount of air may be proven to be considerably greater, by calculation from the data obtained from the crank-case cards. These cards are of the form shown in the sketch, Fig. 2. The difference between the volume occupied by the crank-case contents at atmospheric pressure during expansion, and at the same pressure during compression, will represent the volume occupied by the air and steam per stroke (provided the temperature of the crank-case and the quality of the steam is the same at

both instants). This volume is indicated by the length a b on the card, and a b + c d in Fig. 2 represents the fraction of the total piston displacement occupied by the crank-case charge. Now take the figures for Run No. 6 (full load brake). The length on the atmospheric line is 75.7% of the stroke, and the revolutions per hour are 17,010. Then the actual volume occupied by the crank-case charge per hour is 7,025 cu. ft., and if this were all air at the room temperature (72° F.) it would mean, as a maximum, 528 lbs. of air per hour.

For a given charge of air we shall get the maximum amount shown by the card if the water used has become dry and saturated steam and the temperature of the entering air is raised to that of the jacket. Since 41.41 lbs. steam were used per hour, we should have to subtract 1,081 cu. ft. (the volume occupied by this amount of steam at atmospheric pressure) from the volume shown by the card. The net volume then is 7,025 — 1,081 = 5,944 cu. ft. If this is at the temperature of the jacket, 196° F., its weight is 355 lbs. per hour.

So far as we are able to assert positively, the air per hour may be anywhere between 355 and 528 lbs. However, the assumption made in the first case, that all steam is condensed and occupies no appreciable volume, seems unreasonable, and gives an amount of air much too high. The assumption in the second case that the temperature rise is as large as was assumed seems equally unreasonable and gives an amount of air considerably too low. The amount of air actually used is probably about the mean of the values obtained by the two methods, and may, therefore, be closely approximated by assuming a very small temperature rise and the condensation of no steam. The method of calculation then is as follows: From the total volume of air and steam at atmospheric pressure, found from the crank-case cards as indicated, we subtract the volume that the jacket-water would occupy if it were evaporated to dry and saturated steam at atmospheric pressure. This gives the "actual" cubic feet per hour. We then assume that the air has a temperature rise (over the room temperature) of about 25° F. at full load, 10° F. at no load, and intermediate values for other loads; on this basis the "actual" volume is reduced to volume at standard pressure and temperature.

Efficiency of Engine and of Set.—The mechanical efficiency of the engine and the total efficiency of the set may be calculated by two methods. We may consider the loss of power in the crank case compressor as a thermodynamic loss, i. e., as an essential part of the cycle, in which case the efficiency is the Delivered Horse-Power divided by the net Indicated Horse-Power. The results obtained by this method are denoted "Efficiency A." We may, on the other hand, consider this loss as a mechanical one due to the wasteful mechanical operation of driving out the exhaust gas and introducing the new charge, in which case the efficiency is equal to the D. H. P. divided by the I. H. P. of the working end. The results obtained by this method are denoted "Efficiency B." The latter seems the more reasonable of the two methods, especially when, as in the present case, the crank-case power represents a considerable loss of work, none of which is recovered in the working cylinder. This is evidently a loss, the magnitude of which will depend largely on the details of mechanical construction. In order to furnish means of comparison with the results of other tests calculated by either method, both efficiencies are given and indicated as has been above remarked.

Horse-Power Lost, in engine and dynamo, being taken as the difference between Delivered Horse-Power and Indicated Horse-Power, may also be calculated on the two assumptions that the crank-case horse-power is a thermodynamic or a mechanical loss. If calculated by the latter method, the horse-power lost will include the loss due to fluid friction. The results by both methods are given.

Thermal Efficiency from Indicated Horse-Power.—This is equal to the thermal equivalent of the I. H. P. divided by the heat supplied per hour. Since one horse-power per hour represents 2,545 h. u., the thermal efficiency from the I. H. P. will be

(I. H. P. × 2,545) ÷ (B. T. U. per hour).

It is evident that this also will differ according as we view the crank-case cycle as an essential part of the thermodynamic cycle or not. For purposes of comparison with the thermal efficiencies of four-cycle engines, or with the ideal thermal efficiency, the efficiency calculated from the working end I. H. P. should be used.

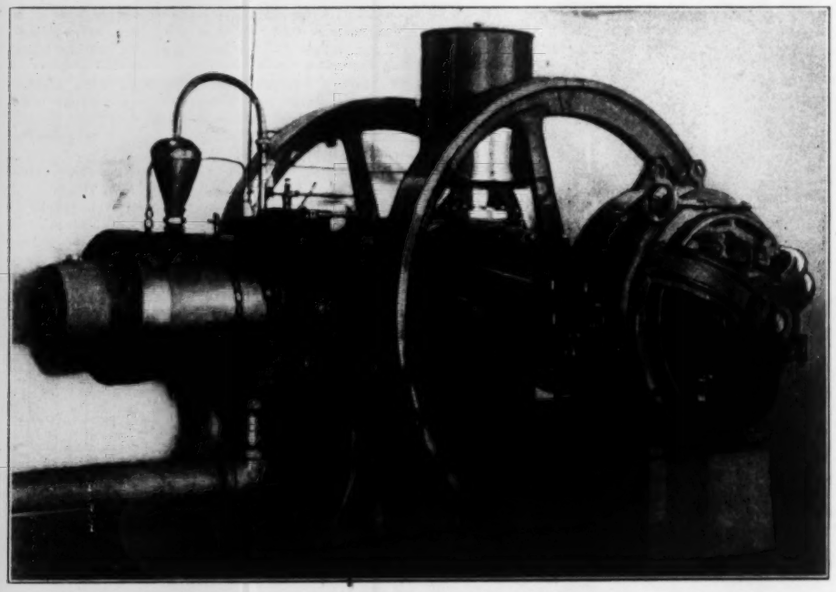


FIG. 6. GENERAL VIEW OF MIETZ & WEISS OIL-ENGINE WITH EVAPORATING JACKET.

Thermal Efficiency from D. H. P. is equal to the heat-equivalent of the D. H. P. (per hour) divided by the heat supplied per hour.

Maximum Thermal Efficiency is the maximum efficiency possible for an engine of the given construction carrying out perfectly the Otto cycle, i. e., compressing adiabatically, heating charge at constant volume, expanding adiabatically, and exhausting at constant volume. It is given by the formula

$$\text{Efficiency} = 1 - \left(\frac{v_1}{v_0}\right)^{0.41}$$

where v_0 is the volume at the beginning of compression and v_1 is the clearance volume.

Heat Absorbed by Jacket-Water.—Since the jacket-water, after being evaporated in the jacket, enters the cylinder and accompanies the charge through the working cycle, the total heat absorbed is the difference between the heat in the water supplied and that in the steam exhausted. Its temperature when exhausted is equal to the observed temperature of the exhaust gases. Its pressure is unknown; however, the pressure at the beginning of the exhaust is shown by the card to be about 15 lbs. per sq. in. at full load, and the difference between the total heat in a pound of steam at exhaust temperature and atmospheric pressure, and at the pressure of 15 lbs., is very small—less than 1% for the full load brake run. The assumption, therefore, that the exhaust pipe pressure is about 5 lbs. per sq. in. above that of the atmosphere cannot introduce an appreciable error. For the total heat given to the jacket-water we have the formula

$$H = W\,[h + .48\,(T_e - T_s) - (T_1 - 32)]$$

where W = water per hour, in lbs.,
h = total heat in one pound of dry and saturated steam at 19.5 lbs. per sq. in.,
T_e = temperature of exhaust.
T_s = steam-temperature corresponding to pressure of 19.5 lbs. per sq. in.,
T_1 = temperature of entering water.

We can divide the heat given to the jacket-water with a fair degree of approximation into the portion it receives while in the jacket and that which it receives while in the cylinder. The heat received while in the jacket will be given by the formula

$$H_j = W\,[h_j - (T_1 - 32)]$$

where h_j = heat in one pound of dry and saturated steam at jacket-temperature.

Since the steam in the jacket is in contact with water, it cannot be superheated and is probably very w[illegible]. The amount of heat found as above is, then, a m[illegible]mum value. Even this is found to be considerably less [illegible]an i[illegible] common in engines of the same size.

The heat absorbed by the jacket-water after ente[illegible]g the cylinder is the difference between the two preceding [illegible]ems.

DATA.

Engine:	
Diameter of piston, ins.	10
Area of piston, sq. ins.	78.54
Length of stroke, ins.	12
Piston displacement, cu. ins.	942.5
Piston displacement from exhaust port closure to inner dead-center, cu. ins.	754
Clearance volume, cu. ins.	188.4
Clearance, per cent. of volume at beginning of compression, per cent.	21.8
Diameter of brake drum, ins.	28
Thickness of brake rope, ins.	1.5
Dynamo:	
Lundell dynamo, compound-wound, manufactured by Sprague Electric Company.	
Rated speed, r. p. m.	2000
Volts at rated speed.	125
Amperes at full load.	68
Output, watts.	8,500
Indicator Springs:	
Nominal scale, lbs. 10 20 80 100	320
Actual scale, lbs. 10.0 20.6 82.0 102.6	320.0
General Data:	
Lower heating value of oil, B. T. U., per lb.	18,520
Specific heat of oil	0.47
Specific heat of air (at constant pressure)	0.2375
Weight of a cubic foot of air under standard conditions (32° F. and 14.7 lbs. per sq. in.), lbs.	0.0807

Tables I. and Table II. (see preceding page) present the results found by the authors in the second series of tests, which were made with brake. The first series, otherwise closely similar, involves the performance of the dynamos, and its results are therefore of less value here. Together with the tables, we reproduce also the indicator diagrams taken during the tests, the curves of mechanical and thermal efficiency plotted from the results, and curves of oil consumption with varying load. With the exception of the indicator cards, these diagrams repeat what is already given in Table I., but the graphical representation of these quantities summarizes the important results of the tests in more compact form.

GERMAN HIGH-SPEED COMPOUND LOCOMOTIVE AT THE ST. LOUIS EXHIBITION.

The results of the celebrated trials of high-speed electric traction on the military railway between Berlin and Zossen, in Germany, have spurred the designers of steam locomotives to action, and designs have been prepared for steam locomotives intended for very exceptional speed. These high-speed experiments were discussed in our issue of June 16. One of the specially designed steam locomotives is a prominent feature in the locomotive exhibits at the St. Louis Exhibition, and is notable in many respects, as may be judged from the view, Fig. 1. It is a three-cylinder compound engine, with four driving wheels and a four-wheel truck at each end. To reduce the air resistance, both engine and tender are enclosed in a sheet steel cab or housing, brought to a wedge shaped point in front of the smoke-box, where the engineman is located. This engine was built by Henschel & Sohn, of Cassel, to the designs of Mr. Wittfeld, and with the approval of the Royal Prussian Ministry of Public Works. Since its construction it has been purchased for the Prussian State Railways, and will be operated on the line between Berlin and Hamburg. It is designed to haul trains of 180 tons at an average or running speed of 80.6 miles an hour, and to attain a maximum speed of 93 miles an hour with lighter trains.

The engine is a three-cylinder compound, with four coupled driving wheels of unusually large diameter (7 ft. 2 5-8 ins.). The front axle is driven by a single inside high-pressure cylinder, and the rear axle by two outside low-pressure cylinders. The two outside cranks are set parallel with each other and at 90° with the inside middle crank. The coupling rod cranks on either side are at 90° with those on the other side, but on both sides they are set at 45° with their respective outside driving cranks. This arrangement is adopted in order to obtain the greatest possible transmission of power from one axle to the other, with uniformity of stresses.

The three cylinders are all of the same diameter, but the inside high-pressure cylinder is set forward between the truck axles, while the outside low-pressure cylinders are set between the truck

and driving wheels. This is shown by the plan in Fig. 2. With this arrangement of cylinders and cranks the effects of the reciprocating weights are very closely balanced, and the nosing movement due to pistons on opposite sides moving in opposite directions is eliminated. At the same time the long but flexible wheelbase reduces any longitudinal pitching motion to a minimum. The crank axle, high-pressure connecting rod, coupling rods and crank pins are of 5% nickel steel.

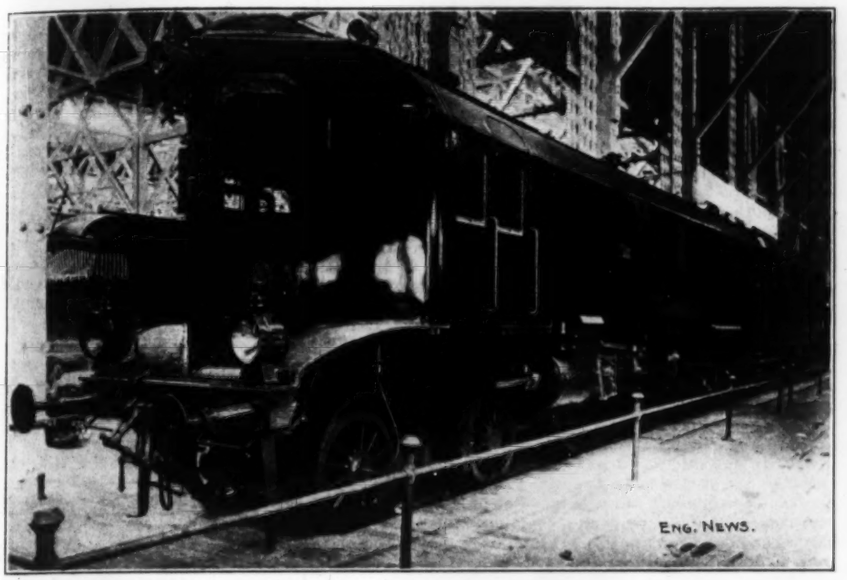


FIG. 1. THREE-CYLINDER COMPOUND HIGH-SPEED LOCOMOTIVE FOR THE PRUSSIAN STATE RAILWAYS AT THE ST. LOUIS EXHIBITION.
Henschel & Sohn, Cassel, Germany; Builders.

Balanced slide valves of the Allan double-ported type are used, set on top of the cylinders, but having their seats inclined transversely. Each valve is driven by its own independent valve gear of the Von Waldegg system, the valve gear of the inside cylinder taking its motion from an eccentric, while those of the outside cylinders take their motion from return cranks. This type of gear was originally invented by Walschaert, but afterwards modified by Von Waldegg.

Fig. 3 shows the valve gear of the inside (high-pressure) cylinder, which differs from the others only in having an eccentric, as above noted. In each case the rod A operates a slotted link, B, rocking on a fixed center. To the sliding block of the link is attached the head of the rod C. The position of the block is regulated from the reversing shaft D by the weighted lever E, to which is attached the reach rod from the screw reversing gear. The rod C is attached to the vertical floating lever F, the bottom of which is connected to the crosshead by the short horizontal rod G, while to the top is pivoted the valve steam connection. This gear is used also, in modified form, on the other German high-speed locomotive at the exhibition.

In starting, the engineman closes a valve between the exhaust passage of the high-pressure cylinder and the receiver. Steam is then admitted through a pressure reducing valve to the low-pressure cylinder, but when the high-pressure cylinder takes steam, its first exhaust automatically opens the valve to the receiver and thus restores the compound working. The screw reversing gear is of the Kuhn system, and gives the low-pressure cylinders a constant admission of 70 per cent, while the admission of the high-pressure cylinder can be varied from 20 to 78 per cent. by the engineman. With the high-pressure cylinder filled to 30 or 40 per cent, and the low pressure to 70 per cent., the work of the high and low pressure cylinders is approximately equal. This degree of admission also corresponds to the nominal capacity of 1,300 HP., which is required to haul a train of 310 tons (including the locomotive and tender) at a speed of 81 miles an hour.

The engine has deep plate frames, in accordance with European practice, but the main frame plates are not continuous, as is shown by Fig. 2. The forward part of the frame consists of two longitudinal plates inside the wheels, and extending from a transverse frame plate at the bumper beam to a similar plate in front of the fixebox. From the ends of this latter frame extend two longitudinal plates outside the firebox, with the upper portion extended forward to be attached to the guide yokes. With this arrangement the boiler and firebox can be set low, as the firebox is between the frames. The engine is mounted at each end upon a four-wheel truck with swing center, the maximum deflection on either side of the center being 1⅜ ins. for the leading and 1⅛ ins. for the trailing truck in passing very sharp curves. The swing of the trucks is controlled by levers and spiral springs, which hold the trucks in their normal position. Stops on the main frames prevent the trucks from slewing in case of derailment. The trucks have plate frames, those of the leading truck being inside and those of the trailing truck outside of the wheels. In both trucks the load is carried by side bearings on springs resting upon the equalizing levers. The driving springs are hung beneath the boxes and connected by equalizers, but are independent of the spring rigging of the trucks.

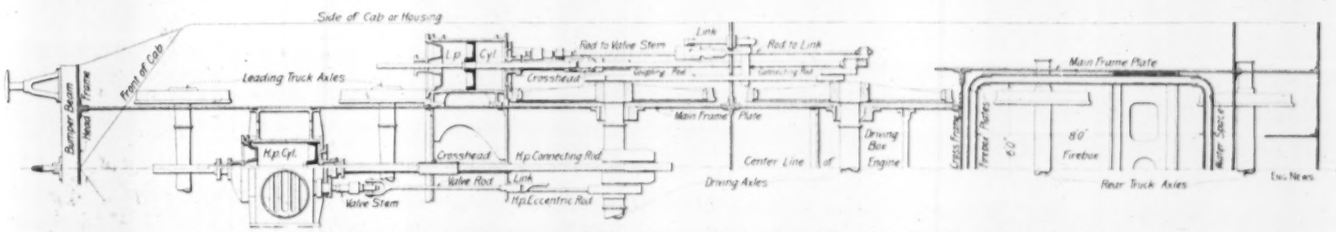


FIG. 2. PLAN SHOWING FRAMES, CYLINDERS AND WHEELS OF GERMAN HIGH-SPEED LOCOMOTIVE.

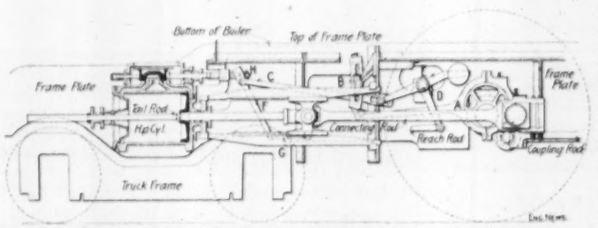


FIG. 3. VALVE GEAR OF GERMAN HIGH-SPEED LOCOMOTIVE.

The boiler is of the wagon-top pattern, but with a very short conical course, just in front of the firebox. There are two steam domes, 7 ft. apart, c to c; the steam is conveyed from the top of the rear dome by a pipe passing inside the boiler to the forward dome, in which is located the throttle valve. This arangement is to ensure dry steam and to prevent water from being carried over to the cylinders. The smokebox is 6 ft. long. At its front end is the main steam pipe to the high-pressure cylinder, and the exhaust from this cylinder passes up to a T-pipe in the top of the smokebox from which inclined pipes lead back to the outside low-pressure cylinders. The exhaust nozzle is set low down, and enters the bottom of a cylindrical spark arrester which is attached to the base of the smokestack extending within the smokebox. Within this spark arrester is a double draft pipe. The firebox is of the Belpaire type, with flat flaring sides and a flat crown sheet with vertical stays. It has two fire-doors, each fitted with a damper which is automatically opened when the door is opened, and when the door is closed the damper remains open for a certain time, being automatically closed by a pneumatic cylinder. The firebox is fitted with the Langer-Markotty smoke preventing device, which consists of a flat spreading steam jet thrown from a nozzle above and between the fire-doors towards the tube plate. Fig. 4 gives cross sections through the boiler and smokebox.

In order to reduce the air resistance to a minimum, the engine is enclosed in a steel housing which is brought to a point to act as a "wind splitter." The engineman's cab is in this pointed portion, forward of the smokebox. To provide for emergencies, however, the fireman can close the throttle by a lever in the rear cab, but he cannot open the throttle by this lever. A passageway on either side connects the front and rear cabs, and there is also a speaking tube between them.

The tender is mounted on a pair of four-wheel trucks and is entirely enclosed by a steel housing similar to that of the engine. A passage on each side affords access to the rear end, which is fitted with a vestibule diaphragm for connecting to the vestibule on the first car. The engine drawbar is attached to the hooked drawbar of the tender, and the tail of this latter drawbar is formed as the strap of a semi-elliptic spring, the ends of which bear against two small spring buffers, whose heads are pressed against the rear of the engine frame. The tender is 32 ft. 5 ins. long over the frames and 10 ft. wide, with the inside passages 20 ins. wide. The height is 4 ft. to the floor and 13 ft. 3 ins. to the roof. The trucks are of 6.56 ft. wheelbase. Coal is taken through two openings in the roof, and water is taken by a hose through an opening at the side.

The engine is fitted with the Westinghouse high-speed brake, having two brake shoes to every wheel, except that the wheels of the leading truck have inside brake shoes only. There are also the Bruggeman compressed air sand-jet apparatus, a water jet for cleaning the tires, two speed recorders, two injectors, a device for cleaning the

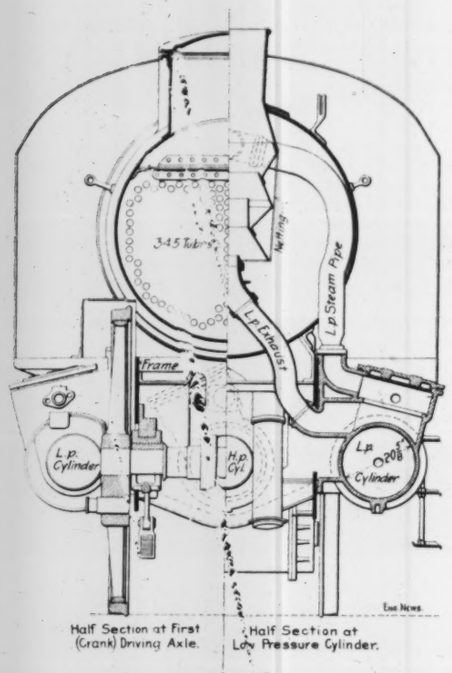


Fig. 4. Cross-Sections of German High-Speed Locomotive.

boiler tubes by compressed air, and apparatus for cleaning the cab windows from the outside without opening them.

The leading dimensions are given below in our standard form:

Three-Cylinder Compound High-Speed Passenger Locomotive: Prussian State Railways.

Type of engine	4—4—4
Driving wheels (4) diameter	7 ft. 2⅝ ins.
Truck wheels (8) diameter	3 " 3⅛ "
Tender wheels (8) diameter	3 " 3⅝ "
Wheelbase, driving	8 " 4¾ "
" truck	7 " 3 "
" engine	37 " 8 "
" tender	23 " 0 "
Leading truck pin to first driver	8 " 0 "
Trailing truck pin to rear driver	6 " 10 "
Weight on leading truck	52,800 lbs.
" " first driving axle	37,400 "
" " second driving axle	37,400 "
" " trailing truck	68,200 "
" of engine, working order	195,800 "
" " engine, empty	174,900 "
" " tender, loaded	128,700 "
" " tender, empty	69,300 "
Cylinders, HP. (1)	20⅝ × 24⅞ ins.
Cylinders, l. p. (2)	20⅝ × 24⅞ ins.
Ratio of cylinder areas	1 to 2
Crosshead and guides	Alligat'r, 2-bar
Connecting rods, length, inside	7 ft. 3 ins.
Connecting rods, length, outside	9 ft. 4 ins.
Coupling rods; front end, solid, slotted; rear end, strap.	
Boiler, type	Wagon-top
Barrel, diameter inside	5 ft. 0 ins.
Domes (2), diameter	2 ft. 8 ins.
Barrel plates, thickness	0.63 in.
Osebox tube plate	1 in.
Height, rail to center line	9 ft. 0 ins.
Smokebox, length	6 ft. 0 ins.
Injectors	Two
Working steam pressure	200 lbs.
Firebox, type	Belpaire
Length, inside; top, 7 ft. 4 ins.; bottom	8 ft. 0 ins.
Width, inside	6 ft. 0 ins.
Side, back and crown plates	0.64 ins.
Tube plate	1 in.
Crown stays	Vertical
Firebrick arch	Yes
Water spaces, width at mud-ring	2¾ ins.
Tubes, number	345
Thickness	0.1 in.
Diameter, outside	1¾ ins.
Length over tube plates	16 ft. 4⅞ ins.
Heating surface	2,776 sq. ft.
Grate area	45.4 sq. ft.
Capacity of tender tank	52,800 gallons.
Capacity of coal space	7 tons.

A NOVEL BLAST-HOLE LOADER.

A recent fatal accident in loading a "sprung hole" with black powder lends particular interest to the device for loading blast holes, shown in the accompanying illustration. On the V., V., & E. branch of the Great Northern Railway, now being built from Grand Forks to Phoenix, B. C., a workman was killed about a month ago in the following manner: A vertical hole had been drilled and "sprung," and six kegs of black powder had been poured into it when the powder clogged the hole. A small hole was then drilled to tap the larger hole. The drill struck the powder and fired it, instantly killing one man and injuring another. Although not stated in the newspaper report of this accident, it is probable that the powder became clogged, due to the presence of water on the sides of the blast hole, down which it was being poured. If so, the accident could have been avoided by the use of the device herewith shown.

The loading tube is made of sections of seamless drawn steel tubing, coupled with inside screw couplings, the sections being in 5-ft. lengths so that any depth of hole can be charged. The discharge tube is made of bronze; is 3 ft. long and provided with suitable openings for discharging the powder directly above the tamping stick which is a piece of hickory 18 ins. long. Each tube is provided with two funnels holding half a keg each, one of which is being filled from the keg while the other is discharging. The funnel has wooden ball valves and gage for feeding the various grades of powder. A part of the outfit is an "exploder placer," which is made of bronze, slotted to receive the dynamite containing the exploders and arranged so as to be attached to the bottom of the tamping stick.

Not only does this device insure that no clogging of the hole will occur in loading, but it is claimed to pay for its first cost in the saving of powder that otherwise lines the sides of drill holes and fills crevices. Moreover, after firing one shot it is possible to gage the powder with accuracy. The device is light, a 21 ft. loader weighing but 21 lbs. The manufacturers are Cope & Cornelius, Orrville, Ohio.

THE HUMIDITY OF THE AIR OF OUR HOMES.

By H. F. Bishop.*

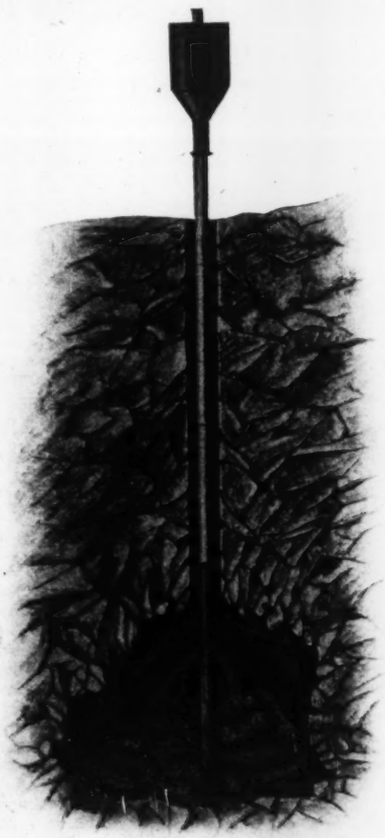
This subject seems to have invited the expression of many opinions, supported by very little actual fact or proof. Much that has been written either violates fundamental principles, or leaves important considerations entirely out of the discussion, so as to be quite misleading. The author, becoming interested in the question, carried on a series of somewhat extended observations during the past winter. Some of the results are given in what follows. The house was a simple frame one, heated by a hot-air furnace, so arranged that the air supply could be taken from the outside, or from a large cold-air register, at will.

The precise effects of different humidities upon diseases is a question which must be left entirely to the medical profession. There is nothing so difficult in the subject, however, as to prevent the layman from forming an intelligent opinion, at least sufficient to keep his own home or office in the most comfortable and healthful condition.

In the first place, the distinction between absolute and relative humidity must be carefully borne in mind. The former is expressed as the number of grains of water vapor per cubic foot of space. The latter is the percentage of vapor present to the total amount required for saturation at the given temperature. The capacity of air to contain water vapor increases quite rapidly with the temperature. This relation is shown by the curved line in Fig. 1. Hence a change in temperature will alter the relative humidity, but will not change the absolute humidity except a slight amount due to the changed volume of the air.

In all heated and properly ventilated rooms, where the difference between inside and outside temperatures is any considerable amount, the relative humidity of the air will be found quite low. Suppose a room to be maintained at a temperature of 70° F., when the outside air is saturated at 32°. From the saturation curve, Fig. 1, it is seen that air at 32° can contain 2.12 grains of moisture per cu. ft. Let 1 cu. ft. of air be admitted into the room and acquire room temperature. It will expand and occupy 1.08 cu. ft., so 1 cu. ft. will contain 1.96 grains. The amount required for saturation at 70° is 4.62 grains. This will give a relative humidity of 24½%, a very dry air, although no moisture has been abstracted in any way, whether the air enters through a furnace or by any other passage. Since relative humidity is an inverse measure of evaporative power, such air will take up moisture with great avidity from every possible source, from furniture, surfaces of the skin, and all exposed water surfaces, so that any hygrometer placed in the room will always show a higher degree of moisture than that obtained by computation as above. The air of the dryest room always has a higher absolute humidity than the outside air. This statement is proven by Table I., which is the result of observations made with the wet and dry bulb hygrometer, the readings being reduced to relative and absolute humidity by means of the proper tables.

Manifestly, the oftener the air in a room is changed, the less moisture it will have time to absorb, and therefore the dryer it will be. This is shown by Table II. On the first day all the air passing through the furnace was taken from outside and the humidity was 39%. On the second day, with the air circulated again and again through rooms and furnace, the humidity was 49%. The moisture in the air out of doors was



A Novel Blast-Hole Loader.

about the same on both days. Herein lies an explanation of the fancy that hot-air furnaces give a "dry" heat, while with steam and hot water we get a "moist" heat. Even in some of the discussions which have appeared in the press on this topic, the hot-air furnace seems to be branded as the worst sinner in the matter of drying out the air.

With properly installed steam and hot water systems, with no leaks and with properly working

*Iowa State College, Ames, Iowa.

TABLE I.—Comparison of Absolute Humidities Inside and Outside.

Inside. Temperature.	Inside. Humidity.	Outside. Temperature.	Outside. Humidity.
72	2.81	34	1.16
69	3.02	38	1.20
64	3.16	40	1.12
74	2.90	42	1.05
68	3.15	44	1.22
74	3.08	32	1.89
71	3.38	32	1.70
77	3.78	38	1.86
78	4.32	36	1.97
76	3.62	34	2.10
73	4.04	32	1.70
72	3.89	30	1.97

air valves on the steam radiators, it is difficult to see how the air can obtain much moisture. It is a fact, however, that with the majority of the systems, especially in small installations, ventilation is left to chance, while a large percentage of furnaces take at least a part of their air supply from outside. Consequently, the supposed merit of steam and hot water is to be attributed to the poor ventilation so often accompanying their use.

The question "what is the proper humidity" has many and various answers. Some argue that since on the balmy and delightful spring days nature gives us an atmosphere 60 to 80% moist, we should maintain a corresponding humidity in our dwellings during the winter months. Others affirm that the most healthful conditions will obtain without any attempt to increase the moisture in the air.

In the first place, it is likely that for a healthy person there is no such thing as an ideal humidity, any more than there is an ideal temperature. The wonderful adaptability of the human system enables the Esquimaux to live in health at — 40° F., and his kinsman under the equator at + 100°. Even at the same place a person may, six months after enduring zero weather, see the mercury at 80 or 90 above. The menace to health does lie, however, in a very sudden change from one extreme to the other. Similarly a person may become accustomed to a moist climate like that of England, or to the dry atmosphere of New Mexico or Southern California.

Since neither a moist nor a dry atmosphere can be said to be unhealthful on that account alone, the question arises as to the effect of a sudden change in the moisture content. By far the most delicate of the organs of the body affected by the air are the passages of the throat and lungs. Whatever the condition of the air breathed, it leaves the lungs at a temperature of at least 90°, and saturated with moisture, or containing 14.8 grains per cu. ft. Consequently, the lungs and air passages are called upon to furnish an amount of moisture given by the difference between 14.8 and the original moisture in the air. Now authorities agree quite well that the amount of evaporation should be kept constant, whatever that amount may be. Mr. Robert Briggs, in a very excellent treatise on this subject, says:

> The establishment of a regime of evaporation, a constancy of secretions, is more essential than uniform temperature.

This condition can be obtained only by breathing air having a constant amount of water vapor; that is, an unchanging absolute humidity. It has been shown that air at 32° and 100% relative humidity contains exactly the same amount of moisture as air of 70° and 24½% moisture. As a consequence, the evaporation from the lungs would be unchanged in passing in or out of doors with such conditions, and would be 14.8 minus 1.96, or 12.84 grains per cu. ft. But suppose moisture to be added to the air of the room so as to bring the humidity up to 70%, as advised by Professor Johnson and others, the absolute humidity would be 70% of 8, or 5.6 grains. The occupant, after breathing such air, requiring the addition of but 9.2 grains, passes suddenly to the outer air requiring 12.84 grains, an instant increase of 3.64 grains.

Nature subjects us to no such sudden changes of absolute humidity, as of temperature. On a frosty morning the air may be saturated and at a temperature of 25 to 32°. In a few hours the temperature may have risen to 60 or 70°, and the relative humidity fallen to 50%, but the absolute humidity will be found quite constant. This statement is supported by the figures given in Table III.

Though belonging still more rightfully to the medical profession, the effect of varying humidity upon disease is interesting. How many consumptives who seek relief in a dry climate are brought home in a few weeks to find their last resting place! Though the excitement and fatigue of travel may be partly responsible, the increased evaporation, affecting as it does the diseased parts themselves, probably contributes its share. This view of the subject confirms and explains the experience of Mr. T. M. Clark, as given in the Engineering News a few months ago (Engineering Literature Supplement, Jan. 14, 1904), to the effect that he was very liable to take cold upon going from his greenhouse, which was kept at 80% humidity, to the much colder air which had about the same relative, but much lower absolute humidity.

From other viewpoints a rather high humidity seems desirable. We are all too familiar with the ruinous effects of dry air upon furniture and interior finish. Those having care of libraries have found that by increasing the humidity they add to the life of book bindings.

Another argument recently advanced for maintaining a high degree of humidity is that of economy in heating. Based upon statements and experiments by Dr. W. M. Wilson, of the Weather Bureau, the Johnson Electric Service Co., which is engaged in the manufacture and exploitation of the humidostat and humidifier, gives us the following:

> With a temperature of 65°, the air being properly moistened, one is as comfortable as with 70° F. when the air is too dry. In this way we waste an enormous amount of fuel. Not less than 10 to 15% of the coal we use is wasted unnecessarily.

Dr. Wilson himself says:

> But to be conservative and avoid the possibility of any unpleasant results from condensation, our dwellings could be heated to 65°, with a relative humidity of 50%, and still save 12½% of the present cost.

Granting these statements as to comfort at 65°, since they are well proved by heating practice in England and on the Continent, where a high humidity is natural, does it not seem strange that nothing is said by either of these parties as to the amount of heat required to evaporate the water needful to maintain the humidity specified? Let us make a little calculation along this line. Suppose the case of a room 14 × 16 ft. × 10 ft. high, having half of the wall surface exposed, with four windows of 12 sq. ft. each. Let ventilation be provided for three persons at 2,000 cu. ft. per hour each. Dr. Wilson gives 30% as an average inside humidity for ordinary winter weather. To increase this to 50% will require the addition of an amount of vapor given by 20% of 6.8, the saturation weight for 65°; or 1.36 grains to be provided for each cu. ft. of air per

TABLE II.—Comparative Effect on Humidity of Taking Fresh Air from Outside and of Circulating the Same Air Continually in the Heating System.

	Outside. Temperature.	Outside. Absolute Humidity.	Inside. Temperature.	Inside. Absolute Humidity.	Inside. Relative Humidity.
		Fresh Air Inlet Open.			
March 22					
6:00 a. m.	34	2.06	60	2.53	..
7:00 "	34	2.06	68	2.25	..
8:30 "	37	2.25	67	2.03	..
Average	35	2.12	65	2.27	39
		Fresh Air Inlet Closed.			
March 23					
6:30 a. m.	28	1.82	57	2.34	..
7:00 "	30	1.97	65	3.33	..
8:00 "	35	2.14	72	4.60	..
Average	31	1.98	65	3.48	49

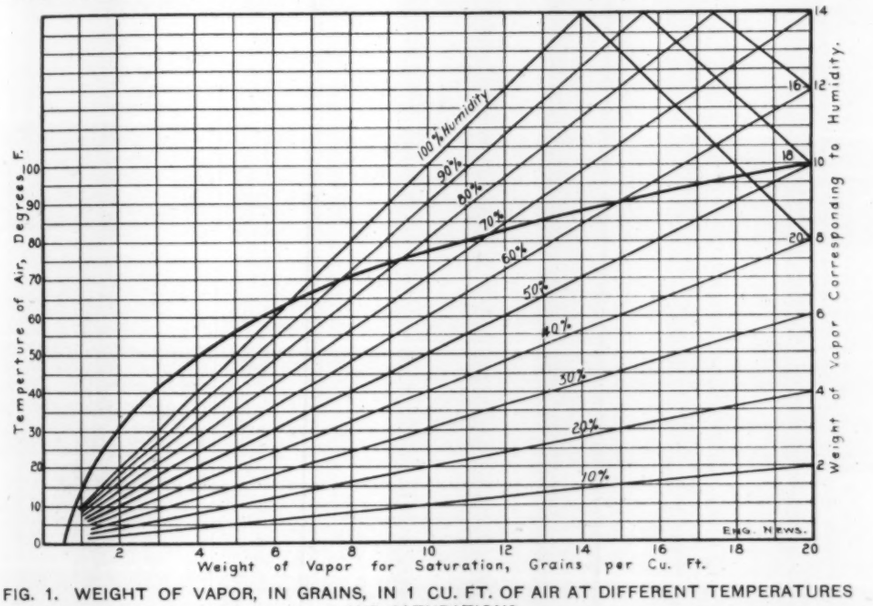


FIG. 1. WEIGHT OF VAPOR, IN GRAINS, IN 1 CU. FT. OF AIR AT DIFFERENT TEMPERATURES AND SATURATIONS.

(From a table prepared for the Smithsonian Institution—S. M. Coll. 1859—by A. Guyot. Based on Regnault's Values.)

TABLE III.—Constancy of Absolute Humidity Outside.

Temperature.	Humidity. Relative.	Humidity. Absolute.
44	100	3.30
52	76	3.34
61	60	3.54
69	43	3.31
72	41	3.48
34	51	1.2
38	48	1.3
40	40	1.15
42	34	1.1
49	37	1.5

TABLE IV.—Effect of Water Pan on Humidity. Results of Five Experiments in Room Containing 1,000 Cubic Feet.

Inside. Normal Humidity, per cent.	Inside. Increase by Evaporation, per cent.	Inside. Evaporation, lbs. per hour.	Outside. Temperature.	Outside. Humidity. Relative.	Outside. Humidity. Absolute.	Outside. Wind, miles per hour.
34	8	1⅛	47	49	1.85	17
42	15	1¾	32	85	1.70	13
39	9	⅞	..	....	....	6
40	5	⅝	42	86	2.70	..
45	13	1¾	57	30	3.00	..

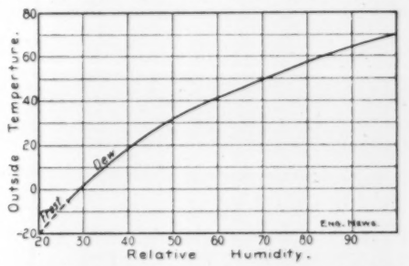


Fig. 2. Maximum Relative Humidity Attainable in a Room at 70° F., Without Causing a Deposit of Moisture on the Windows.

(Assuming that the temperature of the glass is the average of the inside and outside temperatures.)

hour will be required to secure the ventilation specified, making necessary an evaporation of 8,160 grains, or 1.16 lbs. per hour. At whatever temperature the evaporation may take place, the water vapor leaves the room in company with the air at room temperature, and if we assume the water to enter the evaporating pan at that temperature, we are losing just exactly the latent

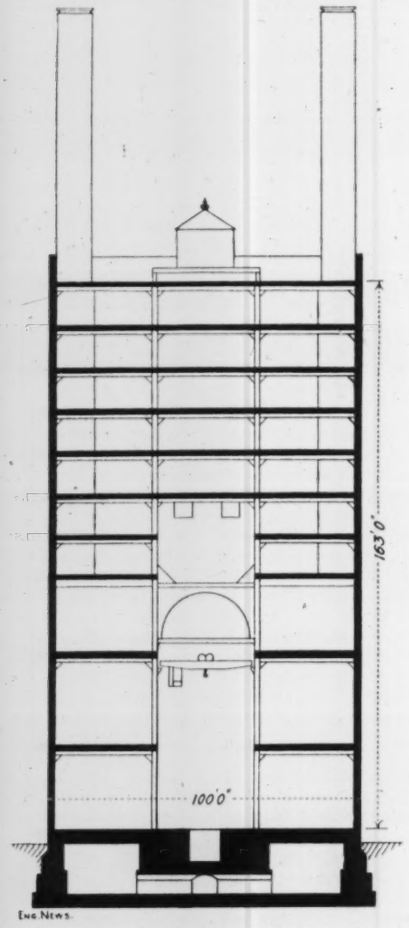


Fig. 1. Section of Phipps Power Building, Showing Steel Stacks.

heat of vaporization at 65°, which gives 1,238.8 B. T. U. per hour.

On page 59 of "Heating and Ventilating Buildings" Prof. R. C. Carpenter gives the following formula for heat required:

$$h = \left(\frac{n}{55} C + G + \frac{1}{4} w\right) t.$$

Where
n = number of air changes per hour.
C = cubic contents of room.
G = exposed glass surface.
W = exposed wall surface.
t = difference in temperature between inside and outside air.

Making the substitution required from the conditions of the problem we have

$$h = 220\ t.$$

Now the saving is to be 12½%, based on that required to heat 70°. We then equate 12½ of 220 to the heat required for evaporation:

12½% of 220 t = 1,238.8
t = 45. 70 − 45 = 25°.

So with an outside temperature of 25° the saving in heat effected by the 5° lower temperature will just suffice to evaporate the necessary water. At a lower temperature than 25° this calculation would show a slight margin of heat saved, although we would not be likely to have an initial humidity of 30%.

This feature has been persistently disregarded by writers on the subject. Professor Kinealy, in an article on the subject, passes it over in silence. In his paper before the Heating Engineers, January, 1904, Prof. R. C. Carpenter calculates the evaporation required to maintain a given humidity simply from the air change. Some have discovered the practical side without explaining it. Mr. Oldacre, in the discussion on Professor Carpenter's paper, said:

> I found that by evaporating 68 lbs. of water, or about 8½ gallons a day, the relative humidity was raised only 5%.

From 35 to 40%, he says later. The room referred to contained 12,000 cu. ft. In the Engineering Literature Supplement to Engineering News for Dec. 10, 1903, Mr. Andrews says:

> The writer has evaporated as much as 15 lbs. of water in eight hours in a large steam-heated room of 17,000 cu. ft. capacity, with a relative humidity of 52.4% at the beginning of the experiment and 51.8% at its ending. The external temperature ranged from + 8° to + 21° F.

The effect which the evaporation of a quantity of water in a given time will have upon the humidity of a room depends upon many conditions, as the temperature and humidity outside, velocity of the wind, amount of ventilation provided for, and tightness of the house, thus making it almost impossible to deduce any rule. The results of a number of experiments are given in Table IV. In carrying these out, the normal humidity was first noted, then the air of the room was rendered more moist by keeping up a noted rate of evaporation by means of an electric heater. Tests were made of several furnaces furnished with water pans, but in all cases the evaporation was so slow as to be of no value in increasing the humidity of the house heated. The usual fault lies in making the pans too small and placing them down so low that they get a very insufficient amount of heat.

A further difficulty encountered in attempting to maintain a high degree of humidity is the condensation of moisture upon the windows. The curved line in Fig. 2 shows approximately when this would occur, assuming still air outside. A strong wind blowing against the window would lower its temperature, causing the condensation to begin with a lower humidity. Double windows may make matters either better or worse. If there be a leakage of air from the inside out, moisture will gather on the outer pane when it would not on a single sash. If, however, the leakage be inward, there will be scarcely any trouble.

To read some of the literature on the subject of humidity, one would be led to believe that people are drying themselves up and inviting disease by living in the "desert-like" air of our furnace-heated homes. The author began his work with this idea and expected to find that the humidity indoors should be raised to something near that obtained outside. This opinion has been materially changed. Not only would such a humidity be expensive and impracticable to maintain, but it would be undesirable and inimical to health. Neither does this mean that nothing should be done to relieve the uncomfortable dryness of the air. Mr. Briggs, above quoted, says:

> It is certain from all experience that 5 to 10% moisture can be added to air after it is heated, certainly with much relief, especially to the eyes, with apparently little harm, although such addition may make the occupant of a heated room a little delicate as to the outdoor exposure.

The present writer believes that a humidity of 35 to 50%, depending upon outside conditions, can be readily maintained, will be found sufficient for comfort and conductive to the best health. Few questions can be decided in favor of either extreme. When fleeing from Scylla on one hand, we need to have a care lest we encounter Charybdis on the other. The golden mean is often as good practically as poetically.

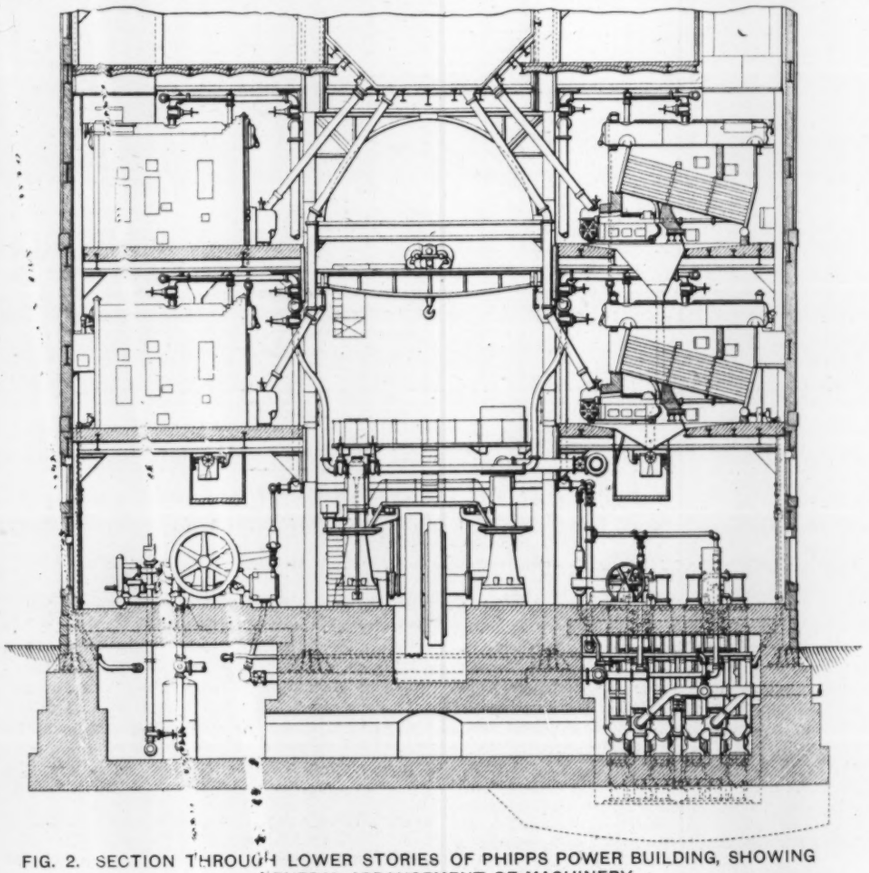


FIG. 2. SECTION THROUGH LOWER STORIES OF PHIPPS POWER BUILDING, SHOWING GENERAL ARRANGEMENT OF MACHINERY.

THE PHIPPS POWER BUILDING, PITTSBURG, PA.*

By Gerald E. Flanagan.†

The primary object which led to the construction of the Phipps Power Building was the furnishing of power in various forms, from a central station to a group of buildings closely adjacent to it upon the property of the owner, some of these buildings being already in existence, others in the nature of projects to be carried out in the future. The building stands in a fairly central position with regard to the properties it is immediately designed to serve, being bounded upon three sides by ground upon which it is the intention to erect structures that will utilize the power which the present installation is capable of supplying. The advantages of such a central plant will be at once appreciated; conspicuous is the fact that the basements of all other buildings are left free to be used for other purposes; and the concentration of power under one management results in the installation of a more efficient type of machinery, and a marked reduction in the number of high-priced attendants.

*Condensed from a paper read at the September Meeting of the Engineers' Society of Western Pennsylvania.
†312 North St. Clair St., Pittsburg, Pa.

BUILDING.

The building in which the power generating machinery is housed is 100 ft. square and 10 stories in height, of heavy steel frame and brick curtain walls with Indiana limestone trimmings. It rests upon a massive concrete foundation, which, in turn, is carried down to a solid footing upon a bed of gravel. There are large windows on all sides which are protected by rolling steel shutters. The machinery and boiler floors are formed of concrete, between the steel beams and over them, while throughout the rest of the building the steel is covered with hollow fireproofing tile, around the columns and arched between the floor beams. These floors are then surfaced with concrete over the fireproofing.

The first three stories are 24 ft. from floor to floor, and are occupied entirely by boilers and machinery; the remainder are 13 ft. in height, and are suitable for light manufacturing; an ample supply of power in various forms being immediately available.

The first, or engine room floor, is nearly 6 ft. above the sidewalk, being so located as to be safely above the highest recorded flood stage, making it about 33 ft. 6 ins. above pool stage of the Allegheny River, and the building is so constructed that even with the highest water there are no openings through which it can flow into the basement. As an additional safeguard the generator foundations are so constructed that even if the basement was filled with water none of it could find access to these machines.

The basement floor is 20 ft. 6 ins. below the engine room floor, and is formed of 4 ft. of concrete over the entire surface placed directly upon the gravel. From this rise rise the outer walls carrying the exterior columns, and in the center a mass of concrete forming foundations for the large engines and heavy interior columns supporting the coal bin and the boiler and manufacturing floors. This foundation is continuous from the front to the back wall, and divides the basement into two parts, except that it is pierced both lengthwise and transversely with large tunnels permitting free communication, and serving as conduits through which the necessary piping may be carried. The flooring over these side basements is constructed entirely free from the framework of the building, and consists of 24-in. 100-lb. I-beams, spaced about 3 ft. 3 ins. c. to c., filled in with concrete and covered with 24 ins. of the same, making a floor 4 ft. in thickness. On the side under the elevator pumps this depth is increased to 5 ft. by the addition of another foot of concrete. This was done to avoid any possible vibration due to the operation of these pumps. The second and third floors extend only along the sides of the building of sufficient width to carry the boilers, except that they connect by galleries at each end. The center space is thus left open to the bottom of the coal bin, which occupies the center of the fourth and fifth floors.

ARRANGEMENT OF MACHINERY.

The arrangement of the machinery will be understood by reference to the illustration. On the first floor, in the center, are the two large engines direct connected to alternating generators, with provision for installing a third unit at a future time. To the left of these are two elevator pressure pumps, also with a place for a third when required. On the right are located two small engines direct connected to direct current generators which serve to excite the large alternators.

At the rear of this room appears the steam end of the vertical pumps which draw the general water supply from the river, the base of these pumps being at a level of 6 ft. 4 ins. below the basement floor; and beneath this level again is a small sump into which all leakage in the basement collects and is pumped into the river. The remainder of the basement is taken up by the boiler feed pumps, of which there are two in place with room for a third; feed water heater with space for a second one, softening apparatus for feed water, exhaust muffler and steam separator, return water tank and small receivers and pumps for various drains. In the basement on the rear side of the building are located the accumulators, a large air tank for cushion on the return line to the elevator pumps, and a pump at the artesian well which supplies the drinking water. In a small intermediate basement in front of the engine foundations are located the filters for the boiler feed purifying system.

On the second floor of the building are located the boilers, and the third floor is arranged so as to be finally used for the same purpose, thus doubling the present capacity. Above the level of the third floor boilers is the coal bin.

The Scaife system of treating tanks and filters is used for purifying the water before it enters the boilers. This apparatus consists of two solution tanks provided with small pumps for forcing the solutions into the precipitating tanks, of which there are also two. These latter are closed tanks, being required to withstand an internal pressure of 200 lbs. Through these tanks the water travels very slowly, the bulk of the impurities settling to the bottom during its passage. From here the water goes to the filters, of which there are four, also of the closed tank pattern; the pressure, of course, being the same as in other parts of the feed water system.

In addition to the more important apparatus above mentioned, there are a number of small pumps used in the daily operation of the plant. There is a pump for discharging the water from the basement sump; another for taking the water from an open tank in which the returns from various lines are collected; a receiver and pump which takes all drips from steam separators and high-pressure lines; and a small receiver and pump which takes the greasy drips from the feed water heater and the grease separator. There is also an air compressor for supplying air to the cushions on the hydraulic system, and oil filters and pumps for the lubricating system.

Coal is delivered at the two large receiving doors on Cecil alley, and falls through heavy cast-iron gratings into hoppers beneath. From there it is raised by two elevators to belt conveyors which traverse the entire length of the coal bin. Moving trippers travel the full length of the conveyors and distribute the coal evenly along on both sides.

The coal bin is of heavy steel plate stiffened with I-beams; it is lined with cement plaster upon wire netting, the bottom being built into hopper forms from each pipe opening by hollow tile such as is used for fireproofing. Twelve pipes, each 12 ins. in diameter, lead directly to the stokers at the boilers, and other openings are in the plates ready for the second floor of boilers.

The present installation consists of twelve Babcock & Wilcox boilers, aggregating 3,600 HP. rated capacity. They are built two in each battery, and furnished with

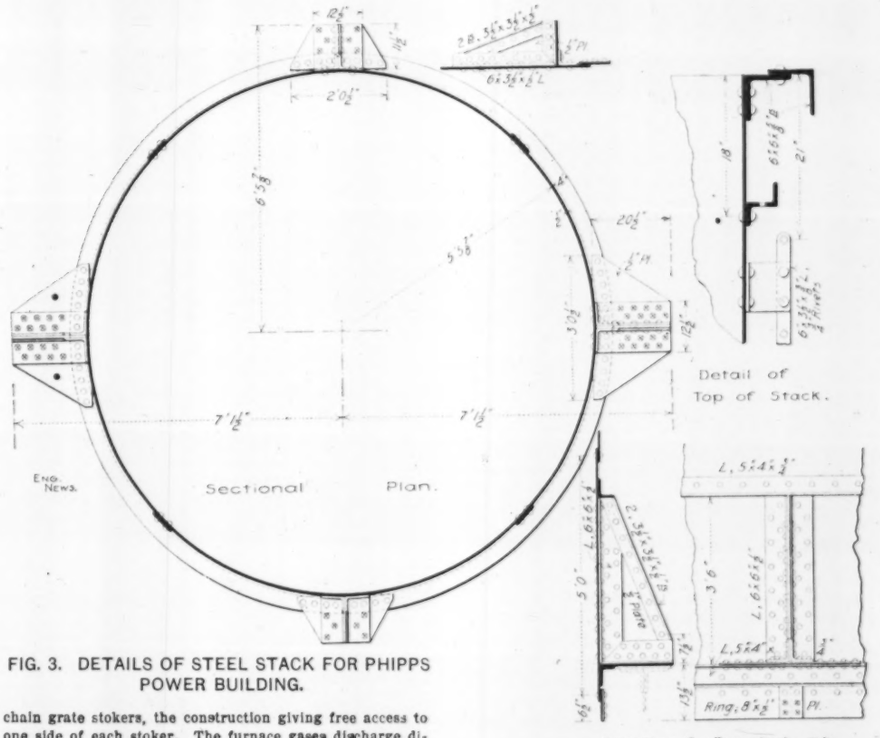


FIG. 3. DETAILS OF STEEL STACK FOR PHIPPS POWER BUILDING.

chain grate stokers, the construction giving free access to one side of each stoker. The furnace gases discharge directly in the rear of the boilers; those from each boiler into a separate vertical flue provided with a damper which swings open of its own weight, and is held in the desired position to check the flow of gases by a chain. The vertical flues are 15 ins. by 10 ft., and rise directly to a 4-ft. by 10-ft. horizontal flue. They have expansion joints about the center of their length.

The horizontal flues each have two expansion joints, and are suspended from the girders above in such a manner as to admit of the requisite motion in the direction of their length. They are provided with numerous cleaning doors.

There are separate stacks for the boilers on each side of the building. The stack proper rests upon heavy girders, but between it and the horizontal flue is a short section or sub-base which connects to the stack through an expansion joint.

The stack is 11 ft. inside diameter, and rises to a height of 200 ft. above the grate bars. It is built of ⅜-in. steel plates, except the bottom ring and the rings where it is stayed to the building at the roof, which are ½-in. There are four substantial brackets at the base which rest upon the steel work of the building, and the top is stiffened by a ring made of two 6-in. by 6-in. by ⅞-in. angles, and below this a ring made of Z-bar for carrying slings for painting. A ladder extends from the roof to the top of the stack. The stacks are not lined. Around the 11-ft. stacks are tile wall inclosures 13 ft. square, permitting the intervening spaces to serve as ventilating shafts for the engine and boiler floors.

THE PIPING SYSTEM.

The piping system is never the least important part of a power plant, and in this instance it really constitutes itself a leading feature.

Water Supply and Boiler Feed.—On the bank of the Allegheny River is a massive concrete block which forms the intake for the water supply, and from this point two 16-in. cast-iron bell and spigot pipes lead to the supply pumps in the power building. The inner end of the intake is flush with the surface of the wharf and covered with a heavy cast-iron plating. The screen, the tops of which are below the water even at pool stage, are formed of angle bar frames with bronze wire netting, and are dropped into slots formed in the concrete. In front of the screens is a grating made of round wrought-iron bars 2½ ins. in diameter; these are dropped into sockets in massive cast-iron beams and may be removed singly.

Discharging into the river at a point below the intake is a private sewer from the Power Building, made of 10-in. bell and spigot pipe.

At the supply pumps the system of valves is such that each of the pumps may draw from either, or both, of the intake pipes, and also that the pumps may discharge into either of the intake pipes while drawing water through the other one, for the purpose of blowing out any sediment which may collect in them. From the discharge side of the pumps a 16-in. main leads to the various properties, a 6-in. branch being taken off to supply the general needs of the power building, while a 10-in. line leads to the boiler feed pumps. From the feed pumps an 8-in. line goes to the feed water heater, and from there a 6-in. line takes the hot water to the purifying system, and then reaches the boilers through various smaller branches. Valves are arranged so as to by-pass the heater, treating tanks and any one or all of the filters, so that the plant is operative with these devices entirely out of commission. The feed water mains are of wrought iron, and the smaller branches at the boilers are of brass. Near the feed water heater is a nickel-seated water relief valve set at 220 lbs.

Steam Pipes.—Steam from the boilers is collected in 14-in. headers on either side of the building, and these are connected at one end. From both headers 10-in. lines lead to the separators at each of the large engines, so that each engine may draw steam from any or all of the boilers.

Exhaust Steam Pipes.—Exhaust steam leaves these engines through 18-in. pipes which are collected into a 24-in. line and finally into a 30-in. main and stack, which terminates in a large exhaust head above the roof of the building. Since exhaust steam is to be used for heating during a greater part of the year there is a 30-in. back pressure valve located in the horizontal main; and behind this valve are collected branch lines from all the steam-using machinery, but arranged in such a way that while the smaller machinery is working under back pressure the main engines may exhaust freely to the atmosphere, and by operating the proper valves the exhaust from these engines may also be forced into the steam heating mains.

Waste Steam.—The steam wasted through the safety valves is collected into two 8-in. mains which in turn discharge into the 30-in. stack. The branches enter these mains at an angle of 45° to permit an easy flow of steam.

Boiler Blow-Offs.—From the boilers on each side of the building the blow-offs collect into short 4-in. mains, and these in turn join and form two 5-in. lines which discharge into the private sewer. A branch from the filter blow-offs also leads into one of these 5-in. lines.

Hydraulic Lines.—The elevator pressure pumps discharge into 8-in. pipes, and these lead into a 10-in. main, from which branches are taken to the pressure side of the machines. A 6-in. branch is also taken to the accumulators, and on this branch is located a large air chamber fitted with a valve to prevent the air from escaping should the pressure in the line fall from any cause. The return water from the elevator cylinders comes back to the power building through a 14-in. bell and spigot pipe and goes directly to the suction side of the pumps, the portion of the line within the building being of galvanized steel pipe. There is a large air tank on this line to cushion the shock of the moving body of water. A 6-in. branch from this line goes directly to a wooden tank above the roof of the power building. This tank acts as a reservoir, and its altitude is sufficient to maintain a pressure of about 75 lbs., against which the machines must discharge. The object of this arrangement is to guard against the possibility of the cylinders emptying themselves, as they are placed vertically and contain a column of water of much greater height than the atmosphere would support. The large operating valves of the elevators are moved by cylinders operated by small pilot valves, and these small valves take water from the 75-lb. line and discharge it at atmospheric pressure. This water returns to the open tank and is saved, as it is of value, having been previously treated and filtered.

Return Water Lines.—A small amount of live steam is used in the office buildings for heating water, and the condensation from this is returned to the open tank, as is also that of the exhaust steam from the heating system and the discharge from the elevator pilot valves. The water from this tank is pumped through a 4-in. pipe to the tank above the roof, replacing the loss in the hydraulic system. When the roof tank is full, a float operated stop valve closes, and the pressure rises sufficiently to force a check valve in a branch line leading to the feed water system, entering it behind the heating and purifying apparatus.

The clean drips from steam separators, etc., are pumped directly into the feed pump discharge, and the oily drips from the grease separator and condensation in the feed water heater into the elevator pump suction line.

Piping Details.—With the exception of the high pressure hydraulic lines all valves and pipe fittings of a given size in this building are interchangeable, from the smallest size up to 14 ins., this being the largest size used for any purpose other than exhaust steam and a few fittings directly connected to the main supply pumps. The result is that any valve or fitting can be used in any part of the plant provided it is the proper size. Aside from the hydraulic lines, all valves and fittings are plain faced, the flanges above 6-in. being rolled steel, the fittings cast iron. All flanges and fittings have machined surfaces for bolt heads and nuts, and the under sides of bolt heads and nuts are faced. The bolts are made from refined wrought iron. All bolt holes are drilled, the number of holes being four in the small sizes and some multiple of four for the larger ones. The cast-iron flanges are threaded in the usual way, and the rolled steel ones have grooves into which the pipe is penned. The pipe hangers are entirely of forged steel, and are of a very substantial character; they are provided with turnbuckles for adjusting the length.

The flanges and fittings on the hydraulic lines are of a type especially designed for this plant. The flanges are screwed to the pipe, and are then turned in the lathe in such a manner as to leave the pipe and a portion of the flange immediately surrounding it projecting a considerable distance from the face. This projecting portion is slightly curved on its face, the highest part occurring on the pipe itself, and between these pipe ends the heavy copper gasket is compressed. It will be seen that there are no male and female joints in this system; all flanges of a given size are alike, a corresponding projection being formed upon the fitting. All the fittings are steel castings, the flanges being of forged steel. The elbows are of long sweep pattern and the tees are strengthened with heavy ribs. In order that the gasket may center itself readily, its outside diameter is made equal to the inside diameter of the bolt circle. A few of the bolts are put in place and the gasket slipped in between the flanges, the remainder of the bolts are then inserted and the joint tightened.

The power building requires to be supplied with coal, and this done, it is able to return power in various forms, such as electric current, alternating and direct; steam at 150 lbs., or any lower pressure; water at 150 lbs. or at 850 lbs.; and compressed air. At present these lines are taken through an underground conduit to the Bessemer building. In the future the ground through which this conduit runs will be covered with tall buildings, and the pipes will then appear in the basement of one or more of them, being already provided with branches from which lines may be taken to supply the buildings.

The engineering and architectural designing, as well as the superintendence of construction throughout, was in charge of Julian Kennedy, Engineer, Pittsburg.

THE BURT CONTINUOUS WATER-SOFTENING PROCESS.

In many cases where water-softening plants are to be installed, more especially for industrial or manufacturing plants, it is desirable to reduce the cost and the space occupied as much as possible, and in order to meet the demand for a compact and low-priced plant, a new system of continuous treatment has been devised by Mr. C. S. Burt, President of the Tweeddale Water Softening Co., 1504 Fisher Building, Chicago. The Tweeddale intermittent system was described and illustrated in our issue of July 2, 1903.

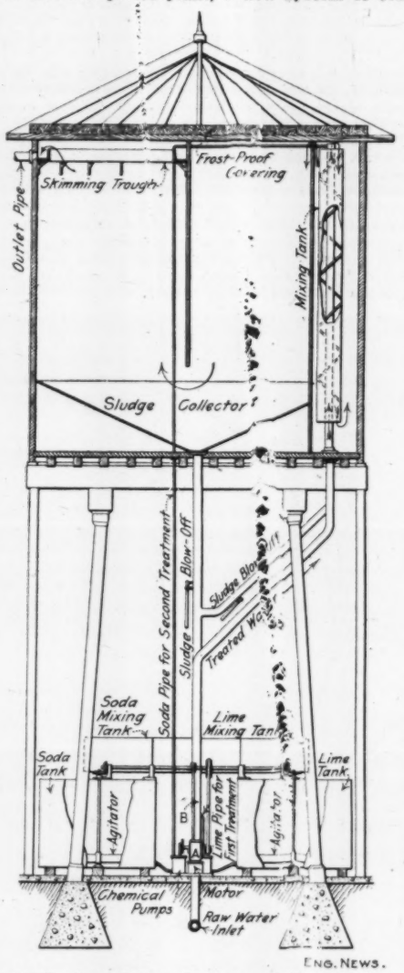


Fig. 1. Section of Burt Continuous Water Softening Plant.

Tweeddale Water Softening Co., Chicago, Builders.

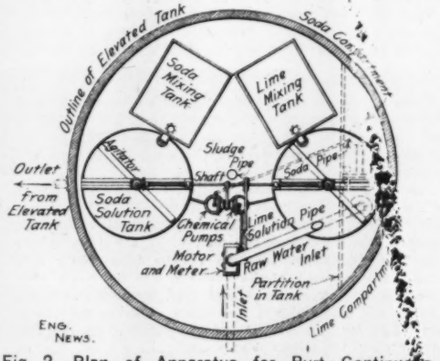


Fig. 2. Plan of Apparatus for Burt Continuous Water-Softening System.

In the Burt system, which is designed for railway water stations as well as industrial plants, the only space occupied is that for the storage tank and tower, and all the machinery is on the ground, where it is readily accessible. The ordinary tank may be divided into two sections, one for the treatment and the other for the storage of water; or separate tanks may be used, as best suited to the condition in each case. In the accompanying cuts, Figs. 1 and 2, the tank is used only for treatment.

The raw water on entering the apparatus operates a motor, A, which drives the two chemical pumps and the agitators in the tanks for the lime and soda solutions. This motor also measures the quantity of water, and at each stroke the pump forces into the supply pipe at B the proper quantity of the reagent required to separate and precipitate the scale-forming elements. The water is discharged at the top of the cylindrical mixing tank at C, and passes slowly downward through this tank, which contains a series of baffle plates (or the Tweeddale compressed air system) to ensure a thorough mixture of the water with the chemical. The water then rises in the small compartment surrounding the cylindrical tank and overflows into the top of the main tank, where a vertical diaphragm compels it to pass downward and then up to the outlet. At the top of the tank the water overflows into a skimming trough, from which it enters the outlet pipe.

If a second treatment (with soda) is necessary, the water already treated with lime is delivered at the top of another vertical cylindrical tank (shown in the plan); it passes down through this, up through the second small compartment and then into the main tank, as above described.

A plant on the Burt continuous system with a capacity of 15,000 gallons per hour is now being installed for the Paris Laundry in Chicago, and occupies a space only 20 ft. diameter under a 20-ft. tank.

The Tweeddale Company's business has now been taken over by the U. S. Wind Engine & Pump Co., of Batavia, Ill.

THE FERRIS WHEEL at the Chicago Exposition of 1893 formed one of the features of greatest engineering interest. After the exposition with its crowds of visitors was over, the operation of the wheel became unprofitable and it was sold. The St. Louis Exposition has furnished another opportunity to profitably exploit it, and the present owners of the wheel, the Chicago House Wrecking Co., removed the wheel to St. Louis and set it up on the exposition grounds. The total weight of the wheel and its fittings was some 4,200 tons, and 175 freight cars were required to transport it. So long a time has elapsed since the original description of the wheel was published that the following brief resume of its design and principal dimensions will doubtless interest many readers:

The wheel is built upon the bicycle principle, with immense tension spokes, 2 and 15-16 ins. diam. The wheel is 250 ft. in diameter and stands 264 ft. high. In reality it is two wheels securely braced together. Between the outer rims of these wheels the eleven-ton cars are suspended on 6½-in. pins, 6 ft. long. These cars are 13 ft. wide, 26 ft. long, 9 ft. high and will carry 60 persons each. There are 36 of them, so the total capacity of the wheel is 2,160 persons. At several times in its history the wheel has been filled to its capacity. The axle of the wheel is a solid steel forging, 32 ins. in diameter and 45 ft. long.

The solid bronze bearings upon which it rests are each 6 ft. long and contain nearly two tons of metal. The weight of the wheel is carried upon two four-post towers 6 ft. square on top and 40 × 50 ft. at the base. These in turn rest upon solid concrete and steel beam pillars, which are carried down to solid rock, 26 ft. below the surface of the ground. The towers are anchored to the bottom of this mass of concrete by 2 × 6-in. eye-bars, so that the wheel is perfectly safe, even in the most violent storms.

The side vibration of the wheel in an 80-mile-an-hour wind is less than ½-in. The wheel is run by a double reversing engine with cylinders 30 × 48 ins., capable of developing 2,000 HP. The power is applied through a series of cogs to a sprocket chain which engages wide cogs on the outside of each rim.

Two revolutions are given each passenger, and the time required is from 20 to 30 minutes.

GROSS EARNINGS OF THE NIAGARA FALLS POWER CO., which is doubtless the largest concern in the world engaged in the manufacture and sale of power, were $1,126,423, for the year ending June 30 last. Other income amounted to $114,936 and operating and other expenses were $214,530, leaving a net amount available for payments to security holders of $1,026,829. The fixed charges amounted to $792,560 and $74,331 was spent on improvements and betterments, leaving a balance of $159,938, which was added to the surplus account.

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An exhibit of American railway appliances is to be made in connection with the International Railway Congress, to be held in Washington, D. C., in May next, and an organization made up of officers of the leading firms engaged in the manufacture of railway supplies in this country has been formed to take charge of the exhibition.

As will be recalled by many readers, the International Railway Congress meets only once in five years and this will be the first meeting ever held in the United States. It is probable that over a thousand of the principal railway officers of the world will be in attendance at the Congress, and it will be the greatest opportunity ever afforded to acquaint foreign railway officers with the distinctive features of railway practice in the United States. If the exhibition is given the breadth and scope that would seem easily possible, it should be a factor of great importance in influencing future foreign exports of American railway supplies.

At a meeting of the general committee of arrangements in New York, on Sept. 8, the Chairman, Mr. G. A. Post, President of the Standard Coupler Co., stated that the most desirable site for the proposed exhibition would be on the large open lot between the White House grounds and the Potomac. As it is a government reservation, an act permitting its use must be obtained from Congress; but in view of the importance of the proposed exhibition to the country's export trade, it seems probable that Congress will readily grant the desired permission.

In the current discussion concerning the plans for the Manhattan Bridge over the East River, confusion has arisen in many minds through the similarity in the names of two independent and totally distinct bodies, viz.: the Art Commission of the City of New York and the Municipal Art Society.

The former body, often called the Municipal Art Commission, is an official body, created by the city charter and legally empowered to pass judgment upon the aesthetic merits of any structure erected by the city, in which artistic merit is of importance, such as buildings or bridges, fountains and statues in the public parks, etc., and its approval is requisite before construction can proceed.

The Municipal Art *Society*, on the other hand, is a purely voluntary and unofficial body. It stands on the same basis as the City Club, or the Chamber of Commerce, or the Board of Trade, or any other association of citizens. Unfortunately, the similarity of names has bred confusion in the popular mind, and if we mistake not the Art Commission is being credited by many engineers with a number of actions performed by the Municipal Art Society.

To briefly review, now, the situation respecting the Manhattan Bridge: During the term of office of Mr. Gustav Lindenthal as Commissioner of Bridges he rejected the plans for a wire-cable bridge adopted by his predecessor in office, and substituted plans for an eye-bar cable bridge which plans received the approval of the city's Art Commission. With the change in the city's administration which took place last January, the new Commissioner of Bridges, Mr. Geo. E. Best, decided to abandon Mr. Lindenthal's design and return to the wire cable; and plans for a bridge of this type were submitted to the Art Commission about two months ago. The plans were referred to a committee which reported on July 12 at a meeting of the Commission:

that it had requested the Commissioner of Bridges to furnish and file such definite statement as he might see fit for the reasons for the rejection of the plans formerly approved by the Art Commission and for the substitution of new ones therefor, and also for the extent to which the plans now before the Art Commission have so far been adopted as, subject to the approval of the Art Commission, presumably to be carried into effect, and further recommended that the Mayor be requested to secure the presentation to the Commission of such engineering data and details of the proposed bridge as may form a basis for full and complete action thereon by the Commission.

By vote of the Commission, however, the whole matter was laid over until its next meeting and there the matter stands at the present time so far as acts by the Commission are concerned.

Meanwhile the Municipal Art Society has been actively at work endeavoring to influence the Art Commission to go farther than it has done and to refuse its approval to the new plans for the Manhattan Bridge until they have been passed upon by a commission of engineers. The Society has been in fact conducting an active campaign against the wire-cable design proposed by Commissioner Best, or at least against its adoption without prior submission to an engineering commission.

As our readers are aware, this journal has maintained an entirely impartial attitude throughout the long controversy over eye-bars vs. wire cable; and we have done so for the reason that in our opinion a perfectly safe and good structure, satisfactory from both the engineering and the artistic point of view, can be produced with either design. But even if this were not our position and we were active opponents of the wire cable, we should still be compelled to condemn the attempt to induce the Art Commission to interfere with matters which are entirely outside of its province.

Commissioner Best presented the situation admirably in his official reply to the Art Commission when he said:

The Greater New York Charter requires from your honorable body approval of the architectural or aesthetic features of structures of this kind. The same instrument imposes upon me the responsibility for the design and construction of such works, aided as I am by engineers of experience and skill. The studies of this problem which have been made by these engineers, and my own knowledge of the facts and conditions of the case, convince me that an eye-bar chain bridge should not be built at this site, and that a wire cable bridge is the only suitable one, *and the only one for which I can undertake to be responsible.*

We have italicized the last clause with a purpose, for it expresses a fact which deserves more attention than it has received. The New York charter places the responsibility for the engineering design of bridges with the Commissioner of Bridges, and his engineering staff, and it places it exactly where it belongs. The engineering head of an enterprise should have the responsibility that belongs to his office. To pursue any other course would be unwise business policy.

This question frequently comes up in railway and other corporations as well as in municipal affairs, when a change in heads of an engineering department occurs. It very often happens that the new incumbent of the office finds work planned of which he does not approve, which, perhaps, might have been carried out successfully by the former chief, but for which the new man feels that for one reason or another he cannot be responsible. In any such case the proper course is to give the new man the full responsibility of his position. If he can convince the President or the Executive Committee or in this case the Commissioner of Bridges that a change ought to be made, the change will be and ought to be ordered, without regard to the opinions or the criticisms of these who have no responsibility whatever in the case.

The establishment of the Municipal Art Commission by the new charter of New York City was rightly hailed by all interested in the betterment of municipal government and the improvement of municipal conditions as a great step in advance. The members of the Municipal Art Society must desire to have the Art Commission perpetuated and imitated by other cities; but if they desire instead to see it abolished they could not take a more direct course than their ill-judged attempt to induce the Art Commission to transcend its legal powers and interfere in a controversy over engineering questions.

We do not question the good intentions of the Municipal Art Society members. They are doubtless sincere in their crusade against the wire cable design for the Manhattan Bridge; but we earnestly counsel them not to endanger the reputation of the Art Commission by trying to drag it into the controversy. If the Municipal Art Society wants to take up engineering questions let them do so directly with Commissioner Best and his assistants. Let the Society induce the Commissioner or his superior officer the Mayor, if it can, to seek the approval of an engineering commission for the wire cable design. But if it really wishes to serve the cause of municipal art, it should temper its zeal with discretion and leave the Art Commission to perform the duties conferred upon it by the charter.

Elsewhere in this issue will be found an abstract from the very interesting annual report of Mr. Charles H. Rust, City Engineer of Toronto. We wish to call particular attention to the quotation relating to concrete pavements, for, as far as we know, Toronto is the only city in North America where a street subjected to any considerable traffic is surfaced with concrete. The wearing qualities of this pavement will be watched with interest by all city engineers.

For some years the city of Toronto has been building tar macadam pavements, and that they are giving satisfaction is shown by the construction of more yardage every year. In view of the quality of stone available at Toronto, it appears that plain macadam is not altogether satisfactory, but a question that suggests itself is whether it would not be wise to build a foundation of ordinary macadam, and upon that foundation lay a wearing coat of tar macadam. There is good reason for fearing that the life of the tar binder will be limited to a few years, and that disintegration will occur long before the wear of traffic has decreased the thickness of the pavement materially. If so, it will certainly be more economical in the end to use the tar macadam only for a wearing coat 2 or 3 ins. thick.

A combination of common macadam for the base with tar macadam for the surface should be cheaper in first cost as well as being less expensive to maintain than an all-tar macadam; for the screenings used to bind common macadam are much less expensive than tar, and the labor of placing and binding is no greater.

The Bureau of Forestry of the Department of Agriculture is proceeding in a very practical way to further its ends by giving the free cooperation and advice of the experts on its staff to states, railways, manufacturers and others desiring to undertake forestry work, timber preservation, prevention of forest fires, etc. From the Bureau's field programme for September we learn that in

Idaho three members of the staff are aiding the Northern Pacific Railway officers to prepare a working forestry plan. In Mississippi and Tennessee experiments on the seasoning of loblolly pine, red gum and red oak are under way in cooperation with the Illinois Central R. R. In New Mexico the Southern Pacific and Santa Fe railways are being aided in experiments on the seasoning and treating of ties. In North Carolina and Wisconsin experiments on seasoning and the effect of rafting on poles are being made with the cooperation of the American Telephone & Telegraph Co.

The criticism may be made that the companies who will derive large benefit from work of this class ought themselves to pay for the expert aid necessary to conduct experiments of this sort and bring them to a successful end. The reply to this, however, is that means should be adopted to secure results; and doubtless free expert aid and supervision will do more to advance the actual commercial adoption of timber culture and timber preservation than anything that could be done in the preparation and publication of "public documents" on the subject.

The great economic value to the nation of intelligent forestry work is beyond question; and if by giving free expert service private corporations and land owners are encouraged to expend money in intelligently planned enterprises looking to timber preservation and culture, the Bureau will doubtless accomplish greater practical results than could be obtained in any other way.

According to Hon. John Barrett, our Minister to Panama, the Isthmus is not a good place at present, either for the man in search of employment or the one in search of an opportunity to engage in mercantile or other business. More men of both these classes are flocking to Panama, he says, than can find work to do, and as the cost of living has gone up about 300% in the last six months the position of some of those in search of work is most unfortunate. Either secure your position before you come to Panama or else be sure you have enough money not only to take you to Panama, but to carry you home again, should your search for employment be unsuccessful, is the eminently safe rule which he lays down.

Furthermore, Mr. Barrett gives warning that even when the work of construction is fully under way, there will be no such great opportunities for private enterprise in catering to the wants of the construction force as are sometimes imagined. The Commission estimate that including all who will be employed on the canal and others brought there by them, the total increase in population on the whole isthmus will not be over 25,000; and there are many cities in the United States of that population whose purchasing power will be several times as great as that of the construction force which will be gathered on the Isthmus.

Concerning the climatic conditions on the Isthmus, however, Mr. Barrett is most reassuring: He says:

> There has been hardly a single instance of serious illness among the considerable number of young men who are here in the employment of the canal, while the percentage of sickness among the larger group of laborers employed at Culebra is not greater than that upon similar excavation work in the United States. There has not been a single case of yellow fever for a month, and there is less malaria than is often found in sections of the United States, where there is considerable turning of the soil.

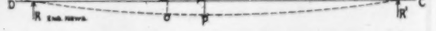
This is distinctly encouraging to those who contemplate going to Panama later and reassuring to those who have friends among the engineers and others already there.

CONSIDÈRE'S THEORY OF REINFORCED CONCRETE IN THE LIGHT OF RECENT BEAM TESTS.

Nearly all theories of reinforced concrete are based on a very limited amount of experimental study. Many theories have no firmer foundation than pure speculation. It was natural, therefore, for engineers, when a theory should be advanced that seemed backed by ample experimental results, to seize upon it, and, in lieu of rebutting evidence, to give it a high place in their regard.

It will be obvious to many designers that we refer in this statement to the experiments and conclusions of Mr. Considère, which have been so widely exploited during the last year or two. Considère's studies have become so well known that an extended explanation of them is unnecessary; but for our present purpose they will be summarized briefly.

In a word, the theory advanced by Considère was that concrete in tension in a reinforced concrete beam can be strained without breaking far beyond the elastic limit, or even far beyond the strain that would break the same concrete if not reinforced. This theory was deduced from experiments in which its author found that a reinforced concrete beam could be deflected by transverse loading far beyond the amount at which a concrete beam not reinforced would break, without causing any apparent failure in the concrete in the tension side. To illustrate the point to be made, suppose a beam, A B C D, supported at R and R' and deflected by a load, or system of loads, to the position E F G H p'K. The neutral axis,



N X, cannot change its length, since there are no bending strains in the fibers in that line, and after flexure it will have a position similar to O P Q, and the parallel plane sections l o and m p will take the positions l' o' and m' p', perpendicular to the new position of the neutral axis, and, since this line is a curved line, l' o' and m' p' will no longer be parallel. The fibers l m will be compressed to a length l' m', and the fibers o p will be stretched to a length o' p'.

Mr. Considère claims that the fibers o p were stretched to an amount greater than the breaking strain of concrete, since he observed a deflection of the beams corresponding to such an excessive stretch of the lower fibers, and did not discover any cracks or failure in the concrete. He then cut out pieces of concrete from the lower side of the beams that had been thus subjected to transverse loading corresponding to strains in the concrete exceeding its ultimate tensile strength, and upon testing them found the concrete uninjured. From these results Mr. Considère concluded that the presence of the steel reinforcement so changes the action of concrete subjected to the tensile stresses of flexure that it can be stretched without breaking many times the amount that it would stretch without the steel reinforcement. It should be noted that these comparisons refer only to the strain or stretch in the concrete, and do not refer directly to the load or bending moment.

So much for Considère's experiments and conclusions. Not all engineers have been willing to accept their truth. They have held briefly that the experiments made were too few in number to warrant, without thorough confirmation, abandoning previously accepted ideas of the action of elastic materials under stress. While maintaining this stand, however, they have had no rebutting evidence to set against the distinguished Frenchman's experimental results, and have, therefore, contented themselves for the most part with waiting for future studies to prove or disprove completely the soundness of their position. They were confirmed in this campaign of inaction by the very reasonable belief that formulas derived from the common theory of flexure, with empirical constants determined experimentally, gave results sufficiently exact for all practical purposes of engineering design in reinforced concrete.

The preceding review of what may appear to many as facts somewhat stale from age has had for its purpose here a clearer comprehension of what seem to us to be among the most important and valuable tests ever made on reinforced concrete beams. We refer to the tests of Prof. A. N. Talbot, of the University of Illinois, published in Engineering News of Aug. 11, and to the even more important tests of Prof. F. E. Turneaure, of the University of Wisconsin, that were published in our last issue.

Postponing for a moment any consideration of the bearing of these tests on the results [illegible] theory of Mr. Considère, a word of praise is manded by their thorough character, and by skill and accuracy with which they were ducted. Whether or not it is agreed that particular tests establish definitely any impor truth, it must be agreed that it is only by careful and intelligent tests that reliable kno edge of the action of reinforced concrete can obtained. It is even more important to obse and retain in mind the fact that these tests sh conclusively that the last word respecting theory of reinforced concrete has by no mea been uttered, and that engineers will do well f time at least, not to pin their faith to a theory which requires alterations in the theory elasticity and of the properties of matter to ex plain it. In making this statement we ar prompted by no desire to belittle unduly th work of Considère, which, on the contrary, de serves the highest praise.

Referring first to the tests of Prof. Turneaure their general result may be summarized as follows: The beams subjected to flexure had been kept under water, and as they deflected under loading, moisture appeared on the surface at some places on the tensile side, apparently coming through cracks. That there were actual cracks at these water-marks was proved by sawing out a strip of concrete containing such a mark, and observing that the strip fell apart at the water-mark. Strips of concrete cut from between water-marks showed, on the contrary, no injury of the concrete. Repeated careful tests made to determine at what point of flexure the water-marks became evident showed that it was when the unit elongation of the concrete was between 0.0001 and 0.0002. As the flexure increased, the water-mark developed into a visible crack at a unit elongation in many cases as small as 0.00035. As will be seen, these results are closely verified by the tests of Prof. Talbot, which show that the concrete and steel act together homogeneously until a unit fiber elongation of from 0.0001 to 0.000133 has been reached, and then a sudden change occurs, the concrete on the lower side of the beam ceasing to act in tension and its load being transferred to the steel.

The natural inference from these tests is that Mr. Considère did not happen to include a crack in the test pieces he cut out of his beams, or if he did include one, attributed its existence to other circumstances than the correct one. But whether the concrete in Mr. Considère's beams did or did not crack, Prof. Turneaure seems to have proved beyond doubt that it cracks in some cases, if not in all. The significance of the phenomenon, if it is universal, is far-reaching, and in pointing it out we can do no better than quote Prof. Turneaure as follows:

> The significance of these minute cracks is an open question. It has been supposed that concrete reinforced by steel will elongate about ten times as much before rupture as will plain concrete. These experiments show very clearly that rupture begins at about the same elongation in both cases. In the plain concrete total failure ensues at once; in the reinforced concrete rupture occurs gradually, and many small cracks may develop so that the total elongation at final rupture will be greater than in the plain concrete. In other words, the steel develops the full extensibility of a non-homogeneous material that otherwise would have an extension corresponding to the weakest section.
>
> The presence of these cracks of course seriously affects the tensile strength of the concrete, and, as they appear at an elongation corresponding to a stress in the steel of 5,000 lbs. per square inch or less, it would seem that no allowance should be made for the tensile resistance of the concrete. Furthermore, if such cracks are present the calculation of the tensile resistance of reinforced concrete by the method used by Considère leads to no useful result. In his tests Considère determines the stress in the steel from measurements of its elongation and then assumes the concrete to carry the remainder of the load. Assuming the value of E to be uninfluenced by the concrete, this would be correct so long as the stress in the steel and in the concrete is uniform between points of measurement. As stated by Considère himself, such results are only average values. But the concrete may be cracked entirely through and yet possess a very considerable average tensile strength over a length of several inches. Obviously in that case an average is of no value; the strength of the concrete is really zero.
>
> In practical design the most important question which arises is how far a concrete may be cracked without exposing the steel to corrosive influences. In this respect it seems to the writer that the minute cracks which appear in the early stages of the tests can have very little influence. However, the entire question of the effect of cracks and pores in the concrete on the corrosion of the steel needs careful investigation.

The last sentence of this quotation points directly at a crucial matter: Shall the minute cracks indicated by the "water-marks" be per-

nitted to form in reinforced-concrete beams? f not, then we are restricted to a stress of from 000 to 4,000 lbs. per sq. in. in the reinforcing teel—a condition which would so greatly increase he cost of reinforced concrete construction as to nake the industry perish. Moreover, it would e a procedure radically out of harmony with ractice as developed up to the present, practice hich we know to be fairly conservative. There s no good reason yet apparent why these "water-narks" should be considered a source of danger. The inability of Mr. Considère to find them is n index of their minuteness. Until farther and very exhaustive studies of the corrosion of steel n concrete show that these cracks may be a source of danger, we will be justified in working, as hitherto, with stresses of 15,000, 20,000 and 25,000 lbs. per sq. in. in the steel reinforcement.

Note, however, what this involves. The experiments of Turneaure equally with those of Talbot give positive evidence that at this stage of loading, and even much below this stage, the concrete below the neutral axis is quite out of action. The weakest point of the beam, which is at the location of a crack, contains no tension material but the steel rods. Our cross-section, then, consists of the compression concrete and the steel tension members. It is these alone which are to be used in the calculation for moment of resistance. The many theories (even before Considère's work), which gave to the tension concrete a certain stress, must be abandoned and the simpler method above indicated must take their place.

The final and essential item in the calculation of reinforced concrete—the position of the neutral axis—is also well illuminated by the two series of tests referred to. Professors Talbot and Turneaure give us accurately computed locations of the neutral axis for different stages of loadings, derived from precise measurements during the tests. We see that above the "critical" or "adjustment" stage, the neutral axis slowly approaches a position six-tenths of the depth above the axis of the steel. The individual tests agree quite well in this. For proportions of beam much different from those tested the location may be otherwise. But in the absence of further tests we can accept the results here offered as covering at least those conditions represented in the tests. Professor Turneaure's computation of the ultimate stress in the steel (which is subject at most to an error of 2% because of assuming a parabolic stress-variation above the neutral axis) is a very satisfactory confirmation of the correctness of the observations. The conclusion is quite evident that until further experiments give better knowledge, we may compute reinforced-concrete beams of customary percentage of reinforcement (½ to 1%) on the basis of 1. No tension in the concrete, and 2. Neutral axis above the center line of the steel a distance equal to six-tenths the effective depth of the beam.

A NOTABLE SPECIFICATION FOR MACADAM ROAD CONSTRUCTION.

Specifications have recently been issued for the construction of many miles of macadam roads in a state which has hitherto done little or nothing in good road construction. The first thing notable about these specifications is their brevity. Less than two pages of large print contain all the provisions governing the grading, macadamazing, telfording and general clauses. Brevity in a specification is commendable, but brevity at the expense of definiteness defeats the whole purpose of the specification. To illustrate we quote the clause governing macadamizing:

Only good solid stone shall be used in macadamizing. Bidders will name the kind of stone they propose using in said work, and also its location. On the prepared roadbed shall be placed the bottom course, extending 8 ft. on each side of the center line, and composed of stone not larger than will pass through a 3-in. ring in all directions. After being evenly spread the course shall be thoroughly rolled with the roller hereinbefore specified until none of the stone move under the roller. All material must be added dry, but water must be applied ahead of the roller. The bottom course must be 5 ins. deep after rolling. After completion of the bottom course, the second course, to be 2 ins. deep after rolling, shall be applied of stone not larger than will pass through a 1½-in. ring in all directions, and rolled as previously directed until firm and solid, water being applied ahead of the roller. The rolling must be done with the utmost thoroughness in both these courses.

The finishing coat shall be 1 in. thick, and composed of rock screenings not exceeding ½-in. in diameter. It shall be applied dry and rolled once before wetting, then alternate applications of water and rolling until finally completed, when the surface must present a uniform appearance to conform to the shape and grade fixed by these specifications and the accompanying plans. In all rolling the roller must start from the side lines of the roadbed and work toward the center, unless otherwise directed.

The foregoing is the longest and most specific clause in these specifications, and might therefore be assumed to be the least open to criticism. Moreover, it governs the most important and most expensive part of the work. But when we analyze the wording to ascertain the kind of material required, what do we find? First, no statement whatever as to what will constitute acceptable road metal, further than that it must be "good solid stone"—a vague generality that may mean a great deal or very little. Second, no statement as to what will constitute acceptable "binder," futher than that "all material must be added dry." Loam, sand, gravel, and even clay are "materials" commonly used for binder, and they are usually to be had for little or nothing. But how can any contractor be sure that, after securing a contract, the engineer will permit the use of any "material" but stone screenings for the binder?

Next we come to another important omission. Nothing is said as to how measurements will be made of the finished macadam. Will macadam driven by the roller into the sub-grade be measured as macadam, or must the contractor make an 8-in. macadam above the original subgrade surface? In sandy subgrades, from 2 to 3 ins. of stone will be forced below the subgrade surface. Who is to pay for this stone?

Not only is this specification defective to a remarkable degree by virtue of its omissions, but it errs almost as badly in errors of commission. After building a macadam layer 7 ins. thick, thoroughly bound and solid, the contractor is required to put on a one-inch "finishing course of rock screenings, not exceeding ½-in. in diameter."

It is true that certain well-known American specifications call for half an inch of screenings to be spread over the macadam, but the purpose of this requirement is merely to protect the fresh macadam from picking up under the blows of horses' calks and to supply an abundance of stone dust to fill any voids that through careless workmanship may have been left in the macadam below. Most engineers do not use any top coat of screenings, and to place a layer an inch thick on top of the road is something for which no precedent or warrant exists. If it is actually placed it will stay there only until passing wheels crush it to powder and it is washed or blown away.

The roller to be used on this work may be anywhere from 6 to 10 tons in weight. The specification reads:

The roadbed must be rolled until firm with a roller weighing not less than 12,000 lbs. nor more than 20,000 lbs.

The contractor is left in the dark as to whether he can use a horse roller or whether a steam roller will be required.

Perhaps the best illustration of all showing the vagueness of these specifications is the clause relating to the method to be used in laying masonry culverts. We quote it in full as follows: "Only best grades of hydraulic cement to be used, one part cement to two parts sand."

Now both Portland cements and natural cements are hydraulic cements. Do we understand that the engineer does not care which the contractor uses, and if this is the case why does he call for such a rich mortar as 1 to 2?

All the appearances would indicate that the author of these specifications wrote them out of his own head, and entirely without regard to standard practice in road construction as illustrated in the road specifications of neighboring states. Originality and the avoidance of blind copying are commendable, but the writer of specifications should at least know what others have done and should not ignore existing specifications in drafting his own.

LETTERS TO THE EDITOR.

Diagram of Tests of Reinforced Concrete Beams.

Sir: The accompanying diagram shows graphically the results obtained on tests of plain and reinforced concrete beams, at the University of Illinois, described in the paper of Prof. A. N. Talbot, which appears in your issue of Aug. 11. The maximum loads and areas of reinforcing are taken directly from Prof. Talbot's table. These are given at the right hand side and top of the diagram. From the loads and the weights of the beams, the values of $\frac{M}{bd^2}$ have been computed, and from the areas of steel used the percentage of reinforcing has also been figured.

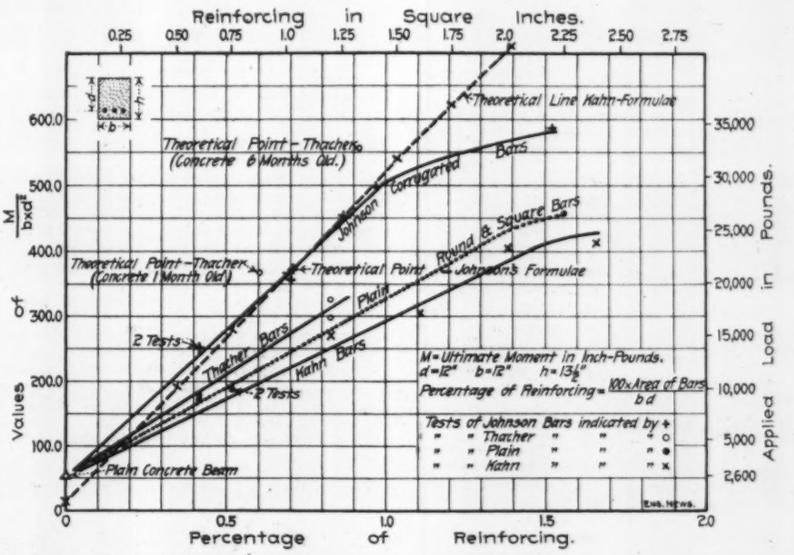

Reinforcing in Square Inches.
0.25 0.50 0.75 1.0 1.25 1.50 1.75 2.0 2.25 2.50 2.75
Theoretical Line Kahn-Formulae
Theoretical Point-Thacher (Concrete 6 Months Old.)
Corrugated Bars
Johnson
Round & Square Bars
Theoretical Point-Thacher (Concrete 1 Month Old.)
Theoretical Point Johnson's Formulae
Plain
2 Tests
Thacher Bars
Kahn Bars
2 Tests
M = Ultimate Moment in Inch-Pounds.
d=12" b=12" h=13½"
Percentage of Reinforcing = 100×Area of Bars / bd
Tests of Johnson Bars indicated by +
" " Thacher " " " ○
" " Plain " " " ●
" " Kahn " " " ×
Plain Concrete Beam
M/bd² Values of
600.0 500.0 400.0 300.0 200.0 100.0 0
35,000 30,000 25,000 20,000 15,000 10,000 5,000 2,600
Applied Load in Pounds.
0 0.5 1.0 1.5 2.0
Percentage of Reinforcing.

DIAGRAM SHOWING RESULTS OF TESTS OF REINFORCED CONCRETE BEAMS MADE AT THE UNIVERSITY OF ILLINOIS.

It is of interest to note that the results of the tests up to certain percentages of reinforcing fall upon straight lines drawn through the point representing the test of the plain concrete beam. There are also shown on this diagram the points corresponding to the theoretical strength of beams of this cross section, according to the formulas of both Mr. A. L. Johnson and Mr. Edwin Thacher. According to their formulas there would be but one percentage of reinforcing for this size of beam of average rock concrete. Also a line has been drawn indicating the theoretical strength of beams according to the formula given on page 10 of catalogue B of the Kahn system.

This diagram may interest those investigating this subject.

Yours truly,
F. F. Sinks.

Chicago, Ill., Aug. 30, 1904.

Paying Contract Laborers by Check.

Sir: Referring to your editorial on paying contractors' laborers with checks: The labor unions generally require payment in cash. In addition to objections which might be made against checks on account of lack of knowledge of the financial condition of the contractor, they object on moral grounds.

The average laborer has hard work on the identification question. He is also afraid to go to a bank. Furthermore the bank opens after he has gone to work and closes before he quits. The average grocery store has a bar in a rear room. Here he must go to cash his check, and for the sake of the wives and families at home, the unions demand payment in cash.

Yours truly, Ernest McCullough.

Chicago, Ill., Sept. 4.

(We did not intend to advocate the use of ordinary bank checks for the payment of workmen; nor the use of checks at all where the work is done in or near some town where men can use money when they receive it. What we had in mind was the payment of men on remote works where the contractor runs a risk in taking the money to the men, and the men run risk of losing their money before they can use it or send it to their families.—Ed.)

More About Making Tape Measurements with One Chainman.

Sir: In reply to Mr. Perkins' criticism of my tape-handle and end-marker, in your issue of Aug. 11, I wish to say that the rear chainman has no reason to consider my tape-handle a mechanical device intended to or likely to dispense with his services. On the other hand, it is intended to make his task easier.

As to the accuracy attainable with the tape-handle, as a rear chainman, I can only say that I have used the appliance on many miles of street railroad, sewers, general street work and cemetery work, and have yet to find any appreciable error traceable to its use. I use stakes 1¼ × 1¼ × 12 ins., driven flush; and I think Mr. Perkins will find, as I have, that a 12-lb. pull cannot possibly disturb them. A No. 15 wire brad 1½ ins. long driven 1¼ ins. in a pine or redwood stake will hold its position perfectly under a pull of 20 lbs. Granted that the stake and nail hold, the handle will certainly perform the functions for which it is intended. The stakes must be driven flush, and the appliance can be used much more successfully on short measurements than on 100 ft. measurements. I know of no other tape-handle that accurately defines either end of that tape; nor do I know of any handle that can be attached or detached as easily as this one.

By the use of this appliance the transitman may at any time verify the work of his chainman if he so desires. For well equipped permanent parties, the hold-fast feature would probably be of very little use.

I hardly think Mr. Perkins intended that his clothes-pin plan should be taken seriously, but if he did so intend, I surmise that the clothes lines in the immediate vicinity of his surveys will come to grief; that is, the clothes will. Why not use fixed stadia hairs, a rod and disk level, and read your total distances at once with more accuracy?

Very respectfully, Thos. N. Badger.

1008 Broadway, Oakland, Cal., Sept. 6, 1904.

Leliavsky's Experiments on Stream Flow.

Sir: Hydrographic engineers, and especially those engaged in river work, will be glad to have the results of the experiments on stream flow made by the Russian engineer Leliavsky and described under the title "Recent Russian Studies of Flow in Rivers," in your issue of Sept. 1, 1904. It is to be regretted, however, that so little is said of the conditions under which these experiments were made.

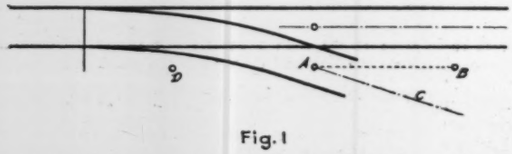


Fig. 1

The behavior of water in an open channel is so dependent on shape, size and slope of channel, unevenness and roughness of bed, proximity to various disturbing influences, that unless these factors are fully described only vague and general notions can be formed from the results.

The comparative results in Table C may be misleading since there is no description of the gaging station where the comparisons were made. It might be inferred that all current meter work in which the direction of the threads of the stream has not been measured are in error by amounts from 2% to 10% from this cause. Such, I am sure, is not the case. It is easy to find places in a stream where the angle between the thread of the current and normal to the cross-section at that point is as large or larger than those given in Tables A and B, but such a place cannot be called a good gaging station. At good gaging stations the threads of the stream are approximately parallel to the banks and perpendicular to the cross-section of measurement. It is not necessary to use any special form of meter to see that this is the case; it is only necessary to observe the behavior of a current meter held with a cable with freedom of motion in all directions in a stream of clear water. It will be seen that while the axis of the meter may frequently change its direction and position a small amount it always remains approximately perpendicular to the cross-section where the channel conditions are good.

We have made numerous tests of current meter work and know that while the results obtained at current meter gaging stations where the conditions are poor may be in error 10%, the error due to the threads of water not being perpendicular to the cross section at good stations is very small. We have several times made simultaneous discharge measurements with two meters of the same kind, one held with a cable free to take the direction of the thread of the current at each point in the cross-section, the other held rigidly with a rod with its axis perpendicular to the cross-section at each point and have found the results practically the same for velocities above 1 ft. per sec. We have also made numerous comparisons of discharge obtained with current meters and standard weir that show that under good conditions current meter work agrees with weir measurements within 2% for velocities above 1 ft. per sec. (See Water Supply and Irrigation Paper, U. S. Geological Survey, No. 95, p. 71). For low velocities we found that the discharge obtained with current meter is less than that obtained by a standard weir and the difference increases as the velocity decreases. This difference is due in part at least to the threads of the current not being perpendicular to the cross-section. For some velocity less than 1 ft. per sec., the stream threads may cease to be approximately parallel to the banks at a good station and their divergence increases as the velocity decreases.

It would add greatly to the value of this translation of Leliavsky's experiments if a map were given showing the contours of the channel for about half a mile on each side of the gaging station where the results given in Table C, were obtained; also the cross-section showing the points where the velocities were measured with the direction and magnitude of each velocity.

Yours respectfully, E. C. Murphy,

Engineer, U. S. Geological Survey.

Washington, D. C., Sept. 7, 1904.

The Relative Value of Withheld Payments and Bonds on Contract Work.

Sir: I notice an editorial in your issue of Sept. 1 relative to retaining a percentage of monthly estimates. I have noticed several articles in your paper recently tending toward the elimination in engineering contracts and specifications of useless and superfluous clauses, and terms which work hardship upon contractors, and you are to be commended for taking up this subject.

It is said that in medieval times contracts were written out laboriously in longhand by a scrivener who received his pay at so much per one hundred words. I am sure that this practice must be responsible for many of our present contract forms. I have noticed recently a tendency in engineers representing prominent companies, and even in lawyers, of laudable brevity and directness in contract forms, and I believe that our contracts in the near future will be materially different in form from those of the past.

There is probably no part of engineering specifications which receives less thought than the part relating to terms of payment, certified checks accompanying bids, and contractors' bonds; and I believe that such are often uselessly severe from the fact that terms are fixed without giving the matter proper consideration, rather than through intent to work a hardship upon any one.

However, so long as contractors are human it will be necessary to surround the contract with such safeguards as will insure that the work is properly carried out. There are three methods of securing good work, assuming of course that the contract is specific and definite: First, intelligent inspection; second, withheld payments; and, third, the contractor's bond. I believe that each has its proper function and that there are very few engineering works in which the first two of the above safeguards are not necessary. I consider a contractor's bond a me[thod] of last resort, and I use it in many of my contr[acts] but omit it whenever possible.

The bond has three important disadvantages: Firs[t] is difficult to be certain the surety is good; second, if surety is good, the question of invalidation comes when changes are made in the contract subsequent to nature which is usually the case, furthermore, su[re] companies which furnish many of the bonds these d[ays] are not in the business with the idea of giving up money that they are not legally obliged to; and, th[ird] the bond must be sued upon in order to recover w[hich] throws the burden of proof upon the city or company.

The withheld payment, upon the other hand, is simp[le] and direct and throws the burden of proof upon the co[n]tractor in case of dispute.

I believe the percentage of withheld payments can [be] made too high. In fact, I think it usually is too high. [In] works involving large quantities of material, perhaps f[ull] payment should be made from month to month in so far as the value of material is concerned, and there are probably some classes of labor which are well safeguarded by intelligent inspection. Upon the other hand there are certain contracts, such, for instance, as laying cast-iron water pipe, where ordinary inspection will not insure good results. A case was recently brought to my notice where 10% would not repair the leaks that appeared upon test. If it had been necessary in this case to sue upon the contractor's bond, it is probable that a hardship would have been worked upon the city.

The chief value of a bond is in insuring that the work is properly started, and in protecting the city or company during the early stages of construction when little of value has been done.

Your editorial speaks of withheld monthly payments, as withholding the contractor's salary. I am not sure that the best interest of all of us are subserved by making it too easy to go into contract work. I have found it necessary to guard against incompetence in the contractor more often than intent to slight work. I believe that the bond and the withheld payment accomplish more for good in keeping out the inexperienced than they cause harm in pinching some contractors, poor but worthy.

Let us cut out the bond wherever possible, but do not deprive us of the withheld payment as a surety of doing proper work. Yours very truly,

Chas. B. Burdick.

1207-1208 Hartford Bldg., Chicago, Ill., Sept. 6, 1904.

Methods for Locating Turnouts and Frogs.

Sir: The letter of Mr. A. M. Haynes in your issue of June 23 suggests the general lack of uniformity in the methods of procedure followed by engineers in setting stakes for the construction of railway tracks leading from turnouts.

In most of the practice the writer has seen, it has been the custom to set the instrument at A, Fig. 1, this point being in the center line of the turnout track opposite the point of the frog. The instrument is sighted toward a foresight B in a line A B parallel to the main track with the vernier set at minus the frog angle, so that when the reading is turned to zero the line of sight is in the center line A C of the turnout track. If, now, the turnout track (or branch track) is to proceed on a curved alinement, deflections may be turned either right or left and the curve located. A stake set back a distance from A equal to the length of the frog separates the switch point and the track foreman lines the curve between the heel of the switch and the toe of the frog either by eye or by using a series of ordinates from the main track rail obtained

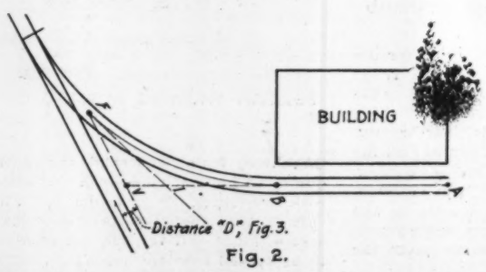
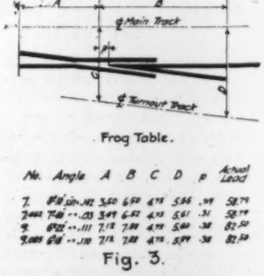


Fig. 2.



Frog Table.

No.	Angle	A	B	C	D	p	Actual Length
7	8°10'30"	5.50	6.50	4.13	5.66	.19	58.79
7.466	7°40'	5.53	6.52	4.13	5.61	.31	58.79
9	6°22'	7.13	7.88	4.13	5.60	.38	82.50
9.085	6°18'	7.13	7.88	4.13	5.59	.38	82.50

Fig. 3.

from a drawing of the turnout furnished by the head of the maintenance-of-way department of the railway.

If the main track is curved it is necessary to set a backsight D in addition to the foresight A making the distance A D = distance A B. The angle between the line A B and the line D A produced is bisected to obtain a line parallel to the tangent to the main track rail at the point of frog and the frog angle is then turned from this tangent line.

The work of locating the branch track is thus done with one set up of the instrument entirely independent of any theoretical assumption regarding the curve in the lead.

To make the curve (if any) in the branch track tangent at the heel of the frog instead of at the point, which many would consider better practice, it is only necessary

to have a table as in Fig. 3, and, using the offset D, Fig. 3 proceed as above described.

In locating close connection between tracks and sharply curved branch tracks running into or along buildings where the exact position of the frog is a critical feature of the work, this position may usually be obtained as follows:

Let A B, Fig. 2, be the center line of a branch track whose position for the distance A B is determined by the building.

Produce line A B toward the main track to point V at distance V B, Fig. 3, from the center line of the main track. Measure the angle V and the distance V B. Let I be the point of intersection of the line A V with the line F I, angle I F V being the frog angle. Now the criterion for the minimum degree of curvature in the curve F B is that the point of intersection I shall be equally distant from the points F and B. This makes the curve F B a simple circular curve.

To solve the problem let F I = I B = T and let measured distance B V = M.

Then V I = M — T; and in triangle F I V we have:

Angle I = Angle V — Angle F, and

$$\frac{T}{\sin V} = \frac{M - T}{\sin F}$$

from which the tangent distance T may be obtained. After thus solving triangle F I V first for T, then for distance F V, the frog may be located by measurement from the established point V.

This method of treatment is applicable to cross-overs between non-parallel tracks, to Wye tracks, and to cross-overs between parallel tracks where frogs of unequal angles are used. (The method fails of course when the track in which the undetermined frog is to be located is curved).

In view of the general usefulness of this problem to the railway engineer and the ease with which it is applied I think it should be embodied in future editions of some of the numerous field books on railway alinement.

Yours truly, R. W. Stewart,
Asst. Engr., S. P. R. R.

Sacramento, Cal., July 23, 1904.

Calculating the Percentage of Cement in Concrete.

Sir: Replying to Mr. Cushman's letter of Aug. 9, regarding the percentage of cement in concrete or mortar, any misunderstanding of the original article came from the fact that I accepted the ordinary interpretation of a 1:2½:5 concrete, as being composed of 5 parts of broken stone, 2½ parts of sand, and 1 part of cement, all measured by volume, with the cement filling the voids in the sand, and the mortar filling the voids in the broken stone. In this case of course it will be admitted that the cement is one-fifth of the resulting mass, which is equal to that of the broken stone. If there is a surplus of mortar, as Mr. Cushman claims, this is simply incidental to the particular case, and does not affect the principle.

Mr. Cushman explained that by a 1:2½:5 concrete he means a mixture of 1 part cement, 2½ parts of solid sand, and 5 parts of solid rock, making a total of 8½ parts. In this view of the case his calculation of the percentage of cement is correct, and I withdraw my criticism, but still think that he stands alone in this interpretation of concrete and mortar. Yours very truly, A. J. Wiley.

Boise, Idaho, Aug. 30, 1904.

Sir: In your issue of Aug. 25 appeared a criticism and answer regarding a previous paper on the relative proportions of cement in rubble concrete and rubble masonry.

I will consider only the principles used by Mr. Wiley and Mr. Cushman in obtaining their results; hence, for convenience, the concrete under discussion will be used as an example.

Of the two, Mr. Wiley's results are more nearly correct than those of Mr. Cushman, although both men make somewhat too positive statements. Mr. Wiley would be entirely correct if concrete mixed 1 : 2½ : 5 always made a perfect mixture; i.e., the sand exactly filling every interstice in the mass of stone and the cement filling the sand voids in a like manner. This, however, is true only in exceptional cases, and varies with the relative degrees of fineness of the various ingredients in the concrete. These degrees of fineness which govern the percentage of voids being unknown to Mr. Wiley, he did the next best, and assumed a perfect mixture, but he should have so stated in his paper, thus protecting himself from criticism.

Mr. Cushman is utterly incorrect in his assertion that the proportions of cement to the whole mass of his concrete are 1 : 8½. His theory, however, is correct for getting the exact proportion of the cement to the whole, if he deducts the percentage of voids from the gaged quantities entering the mixture, but this he failed to do. Had he done so, his stone would have shrunk nearly one-half its bulk and the sand in a somewhat smaller ratio. The ultimate result would then have been the exact proportion desired, to which Mr. Wiley's results would have very closely corresponded.

For practical work Mr. Wiley's method is eminently serviceable but for exact figures Mr. Cushman's theory, but not his figures, will give the desired results.

Yours respectfully, S. P. Brown.

Stratford, Conn., Aug. 30, 1904.

Sir: In the discussion on "The Percentage of Cement in Mortar, Concrete and Masonry" in your issue of Aug. 25, the percentage of cement in concrete and mortar as figured by Mr. Wiley is much nearer correct than the percentage as calculated by Mr. Cushman.

If in the (1 : 2½ : 5) concrete the sand should have 40% of voids and the stone 50%, and the concrete could be rammed thoroughly enough to fill all the voids, then Mr. Wiley would be correct. In practice, however, this is found almost impossible, unless a very wet concrete is used.

It has been found by experience that if the cement be proportioned to just fill the voids of the sand, and the stone be proportioned so that the mortar will just fill the voids of the stone, and the concrete be mixed rather dry that the resulting volume of concrete will exceed the volume of the stone by 6 or 8%. If it be mixed moderately wet the volume of concrete will exceed the volume of stone by 3 or 4%, and if mixed very wet it may be made to amount to just about the volume of the stone; in other words, all the voids will be filled, and there will be no surplus of mortar.

It is best in calculating the amount of cement in the concrete to take the average case, in which the volume of concrete exceeds the volume of the stone by 3 or 4%.

Taking the case of the dam composed of 60% of (1 : 2½ : 5) concrete and 40% of stone, the calculation for the proportion of cement would be as follows:

Volume of cement	1
" " sand, including voids	2.5
" " stone " "	5
Total materials including voids	8.5

To obtain amount of resulting concrete:

Volume of cement	1
" " sand, excluding voids, 2.5—40% =	1.5
" " stone " " 5—50% =	2.5
Total volume of concrete, excluding voids	5.0
Total volume of concrete, including voids	5.2

Proportion of solid concrete $\frac{5.0}{5.2}$ = 96.16%

To obtain the percentage of cement:

Percentage of cement $\frac{1}{5.2}$ = 19.23%

Percentage of sand, excluding voids $\frac{1.5}{5.2}$ = 28.85%

Percentage of stone, excluding voids $\frac{2.5}{5.2}$ = 48.08%

Total 96.16%

To obtain the amount of cement in the dam:

Percentage of concrete in dam	60. %
Percentage of cement in concrete	19.23%
Percentage of cement in dam = .60 × 19.23 =	11.54%

Mr. Cushman is mistaken in his statement that "1 plus 2½ plus 5 equals 8½ proportions; and 1 over 8½ would be the percentage of cement in the resulting dense mass." It is true that it makes 8½ proportions, but it does not make 8½ volumes of concrete, and as we wish to obtain the percentage of cement in the concrete, and not in the proportions of materials before mixing, we must calculate this percentage on a proportion of 1 : 5.2, instead of 1 : 8.5, giving us a percentage of 19.23%, as obtained before.

Mr. Cushman does not seem to take into consideration the fact that the cement goes into the voids of the sand, and the resulting mortar into the voids of the stone, giving the same amount of concrete as there was previously of stone, or very slightly in excess of this amount. This is indicated by his statement that if Mr. Wiley's calculations are true we will have 1 volume, or 20%, of cement; 2½ volumes, or 50%, of sand, and 5 volumes, or 100%, of stone, or 170% in all. This is exactly what would happen if we could mix the materials and keep any from filling the voids of the others; we would then have 8½ volumes, which is 170% of the 5 volumes which is obtained by all voids being filled.

Very truly yours, Walter M. Smith.
Assoc. M. Am. Soc. C. E.

U. S. Engineers' Office, Charleston, S. C., Aug. 29, 1904.

A Formula for Crown Thickness of Masonry Arches.

Sir: On page 43 of your issue of July 14, 1904, Mr. C. Mogamy, of Yonago Hoki, Japan, propounds several queries relative to masonry arch design. He is looking for a practical formula, containing as one of its terms the surcharge. I would like to call his attention to the following empirical formula of mine which contains the term sought for:

$$d = \frac{1}{8}\sqrt{(8 - R)\,10 + 2\,H}$$

in which

S = span of arch, in feet.
R = rise of arch, in feet.
H = depth of surcharge over arch, in feet.
d = thickness of arch at crown, in feet.

This formula is quite simple, requiring merely the span and rise of the arch, and in this respect is much more simple than the one of Trautwine, as given on page 614 of his "Civil Engineer's Pocket Book," 18th Ed., which requires the radius.

In order to test the practical application of my formula

A FORMULA FOR CROWN THICKNESS OF MASONRY ARCHES.

Date of Engineering News.	Location.	Engineer.	Kind.	No. of Spans.	Feet. Span.	Rise.	Radius.	Keystone Depth Crown.	Low's Formula.	Ratio Span Rise.
March 29, 1890.	The reconstructed Conemaugh arch bridge, Little Conemaugh River, Penna. R. R.	Wm. H. Brown....	Railroad...	Semi-Circular, 2	60.0	30.0	30.0	2.67	2.16	0.50
June 21, 1890...	Elyria, Ohio	E. C. Kinney	Highway..	Segmental, 1	150.0	24.0	129.2	3.75	4.45	0.16
Jan. 24, 1891...	Falls of Schuylkill River, Fairmount Park, Philadelphia, Phila. & Reading R. R.	H. K. Nichols.....	Railroad...	Segmental, 1	80.0	26.0	43.77	3.00	2.90	0.325
April 11, 1891..	Turkey River, Elkader, Ia.	M. Tschirgi.....	Highway..	2	84.0	27.9	45.56	3.00	2.96	0.332
April 16, 1892..	Raritan River, Albany Street, New Brunswick, N. J.	Dean & Westbrook	Highway..	7	75.0	15.0	54.4	2.42	3.06	0.20
Aug. 18, 1892...	The Gour Noir Viaduct, Vezere R. R., Province Correze, France.	M. Daigremont....	Railroad...	1	196.9	52.8	118.1	5.58	4.75	0.268
Sept. 1, 1892....	Main Street, Mt. Vernon, Ohio.	A. Cassil.....	Highway..	5	38.0	9.0	24.55	2.00	2.12	0.237
Nov. 10, 1892....	Under freight yards, Dresden, Germany. Height of embankment, 18.8	.....	.....	1	59.0	38.4	....	4.60	1.90	.....
					52.0	13.0	32.5		2.47	0.25
Feb. 2, 1893.....	Court Street, Rochester, N. Y.	J. Y. McClintock..	Highway..	6	52.0	20.5	26.7	....	2.22	0.394
				6	34.43	9.0	20.9		1.99	0.261
Feb. 2, 1893.....	Andrews Street, Rochester, N. Y.	J. Y. McClintock..	Highway..	1	32.43	8.0	20.4	....	1.95	0.246
May 18, 1893....	Boucicault Bridge, Dept. Saone and Loire, France..	.....	Railroad...	5	131.12	16.4	139.4	3.44	4.22	0.125
July 6, 1893.....	North Avenue, Baltimore, Md. Skew	Fred'k H. Smith..	Highway..	3	130.0	26.0	94.3	5.00	4.04	0.20
Aug. 31, 1893....	Cresheim, Fairmount Park, Philadelphia, Pa.	George S. Webster.	Sewer.....	1	116.0	21' 2"	90.0	3.50	3.85	0.181
Dec. 7, 1893.....	Stanislau, Woromienka Ry., Galicia, Jaremcze	.....	.....	1	213.3	53.3	133.2	6.89	5.00	0.25
	Jamna	.....	.....	1	157.4	39.4	98.4	5.58	4.30	0.25
	1st Worochta	.....	.....	1	131.2	32.8	82.0	4.59	3.92	0.25
	2d Worochta	.....	.....	1	113.5	56.8	56.8	4.26	3.00	0.50
	Zemeo	.....	.....	1	72.2	....	....	2.60	....	.....
	Tablonica	.....	.....	1	82.0	....	....	3.60	....	.....
Dec. 7, 1893.....	Vingeaune Viaduct, Eastern R. R., France.	.....	.....	Elliptic 7	127.0	46.0	....	....	....	.....
Jan. 17, 1895...	Pelhamville, N. Y., New York, New Haven and Hartford R. R.	F. S. Curtis.....	.....	1	40.0	10.0	....	2.50	2.16	0.25
March 11, 1897.	Cornell University, Campus.	H. N. Ogden.....	.....	1	65.0	18.0	....	2.50	2.65	0.286
March 25, 1897.	Brockton, Mass., N. Y., N. H. & H. R. R.	F. C. Curtis.....	.....	1	50.0	....	....	....	....	.....
Sept. 9, 1897....	Wissahickon Creek, Philadelphia.	Russell Thayer....	.....	1	105.0	11.0	130.8	3.00	3.83	0.105
Dec. 9, 1897.....	Elizabeth, N. J., P. R. R., Broad Street..	Wm. H. Brown....	.....	2	54.3	11.5	....	....	....	.....
	" " " Grand Street	.....	.....	1	32.0	9.0	....	....	....	.....
	" " " Rahway Avenue	.....	.....	1	39.2	9.5	....	....	....	.....
June 22, 1899...	Bellefield Arch, Schenley Park, Pittsburg, Pa.	Henry B. Rust	.....	1	150.0	36.25	95.70	4.00	4.20	0.242

I give the details of a large number of modern arches, as published in Engineering News from time to time. The close agreement in many cases is quite remarkable.

Mr. Mogamy will also find on this subject much to interest him in the following German work:

"Theorie der Gewölbe, Futtermauern und Eisernen Brücken, Sowol zum Wissenschaftlichen Studium als Ganz Besonders für den Praktischen Gebrauch der Ingenieure." von Dr. Hermann Scheffler, Baurath. Braunschweig: Verlag der Schul Buchhandlung. 1857.

("Theory of Arches, Retaining Walls and Iron Bridges, as well for scientific study as especially for the practical use of engineers," by Dr. Hermann Scheffler.)

Yours truly,

Emile Low, M. Am. Soc. C. E.

Utica, N. Y., Aug. 6, 1904.

THE NEW OUTFALL SEWER FOR LOS ANGELES, CAL., described briefly on p. 150 of our issue of Aug. 11, is built on a new line, except for a distance of 2,100 ft. at the upper end and 6,000 ft. at the lower or ocean end. The upper 2,100 ft. of the old sewer is in good condition and to give the needed increased capacity will be paralleled for that distance. About 3,800 ft. of the lower 6,000 ft. will be torn out and replaced by new work, but the two tunnels through the sand dunes will be continued in use. Construction was started on July 25. A large fill is in progress, and is being built up, alternately, in 9-in. horizontal layers of clay, kept wet by a sprinkling wagon, and 2-in. layers of sand from the tunnel now under construction. It is stated that a firm bank is being secured by this means. Mr. Harry F. Stafford is city engineer, Los Angeles.

THE QUARTER-CENTENNIAL OF ELECTRIC TRACTION in Germany falls in the current year. In 1879 the firm of Siemens & Halske, of Berlin, operated an electric locomotive on an exhibition track in the Berlin Commercial Exposition. In 1904 Germany possesses about 140 electric railway centers, with a total mileage of about 2,400, or an equivalent length of single-track of about 3,600 miles. The equipment comprises about 15,000 cars, about 9,000 of them being motor-cars, the others trailers. In Dresden a mixed trolley and storage-battery system is used; two or three smaller lines still use the battery system. All other lines are on the overhead trolley (or the third-rail) except in Berlin, Dusseldorf and Dresden, where a considerable mileage of underground-conduit lines is operated. An electric elevated railway of the ordinary type is operated in Berlin, and an electric railway of the suspended monorail type is running successfully in Elberfeld and Barmen.

THE EIGHTH INTERNATIONAL GEOGRAPHIC Congress held its opening session in Washington, D. C., on Sept. 8, Commander Robert E. Peary, U. S. N., presiding. President Peary in his opening address defended Arctic exploration as one of the highest and purest fields of international endeavor, and remarked that from a practical geographical viewpoint the South Pole was no less a prize. He pleaded for more practical interest and aid in these directions, on the grounds that there are no 3,000,000 square miles of the earth's surface that do not contain scientific information of much more value than the cost of securing it.

THE NEW RAILWAY BRIDGE ACROSS THE POtomac River, at Washington, D. C., is now completed. The bridge proper is a 12-span structure, made of through trusses of 173 to 203 ft. spans. The total length of the bridge is 2,529 ft.; with a Washington approach 2,600 ft. long, and a Virginia approach 1,800 ft. long. The head of the rail is 21 ft. above the water, and there is a draw-span of 172 ft. The total cost of the bridge was $750,000. The bridge was built for the Pennsylvania R. R. Co. and designed by W. H. Brown, Chief Engineer, with K. W. Craig, engineer in charge. The piers were built by Weand & McDermott, and the superstructure was made by the American Bridge Co.

A FIRE IN AN ERECTION STAGING occurred in Chicago on Sept. 9 and caused damage that will be troublesome to repair. The 18-story First National Bank Building is under construction at the corner of Dearborn and Monroe Sts., and has a front of dressed granite. The Building Department requires contractors to keep the sidewalks clear, and a strong timber platform had been erected over the sidewalk; here tools and materials were stored and work done. The hoisting of material is effected by steam and electric hoists placed just outside the curb line of the sidewalk, the smokestacks of the boilers being close to and a few feet below the timber platform. A spark from one of the smokestacks is said to have set fire to some waste or refuse on the platform, and a shanty standing against the corner of the building was burned. The fire itself was small and of little importance, but it was sufficient to injure several of the granite blocks, the surfaces being flaked and chipped, while the corners and edges spalled off. The repairs will be difficult, as the stone work is completed for several stories above the damaged portion. There are no spark arresters on the smokestacks, although the engines stand at the side of a busy street.

A MIDNIGHT TENEMENT-HOUSE FIRE in New York City, in the night of Sept. 3 to 4, 1904, killed 14 persons and injured many others, two or three fatally. The five-story tenement-house at 164 Attorney St., in the heart of the Jewish tenement district of New York City, was undergoing alterations in the two lower stories. These two stories had been almost wholly torn out, leaving one stairway; the front and rear fire-escape, however, were removed up to the third floor. A fire started in the upper part of the tenement shortly after 2 a. m. of Sunday, Sept. 4. Delay in sending in the fire-alarm gave the fire a good start, and in spite of heroic rescue-work, fourteen persons died in the building. The death-list would have been much larger but for the fact that nearly all adults living there were attending special synagogue service. The firemen found that what was left of the fire-escapes was clogged up with litter; one fire-escape tore from its fastenings during the rescue-work and caused fatal injuries to one fireman. A coroner's investigation is now under way to fix the responsibility for the accident. It is likely that some of the blame will fall on the Bureau of Buildings and the Tenement House Department of the City of New York.

BURNING MUNICIPAL REFUSE on a dump heap at Arverne, L. I., is said to have come near suffocating several persons. During the night the smoke from the burning refuse filled rooms in which a number of persons were sleeping and resulted in the mischief stated.

WOOD PAVEMENT AT INDIANAPOLIS, IND., was recently heaved up just after a heavy rain which followed several weeks of dry weather. On the passage of horses and vehicles over the upheaved pavement they sometimes broke through.

NARROWER PAVED ROADWAYS IN CHICAGO have gained some popular support as a result of suggestions made by Mr. John W. Alvord, M. Am. Soc. C. E., in his recent report on paving made to the Commercial Club of that city.

A SENSIBLE CORNERSTONE INNOVATION is that proposed in connection with the erection of the new City Hall of Newark, N. J., a building that is to cost $1,500,000. Instead of burying the cornerstone as usual, so that its recovery means the destruction of the building, this cornerstone will be a heavy sealed box, so arranged that it can be opened and sealed at will. If there is any use at all for a buried box containing records of future interest, it is well to make these records accessible to the possible user.

LOCOMOTIVES WITH FIREBOX IN FRONT have been in operation on Italian railways for some years, and the Southern Ry. (of Italy) has recently added to its equipment some four-cylinder compounds of this type. They are of the ten-wheel (4-6-0) class, with the cab in front of the truck and firebox and the cylinders at the rear end. The coal is carried in bunkers at the side of the firebox (4 tons capacity), and the tender has a cylindrical tank. The firebox is of the Belpaire type, and extends over the frames. The cylinders are all in a row behind the smokebox (at the trailing end of the frames), and all of them drive the middle driving axle. The arrangement of the cylinders and valves is peculiar. The two high-pressure cylinders are on one side, and the steam distributor is controlled by a single piston valve and Walschaert valve gear. The two low-pressure cylinders are on the opposite side, and are also served by a single piston valve and valve gear. The engine has six driving wheels 75¼ ins. diameter, and cylinders 14¼ × 25⅝ ins. and 23¼ × 25⅝ ins. The weight is 77 tons, with 48 tons on the drivers and 29 tons on the truck. In front of the cab is a small platform with side steps.

FOX AND MORISON CORRUGATED FURNACES have been tested for longitudinal compressive resistance by Prof. C. Bach, of Stuttgart, Germany. The furnaces had the following dimensions:

	Fox.	Morison.
Internal diameter	29.6	29.9 ins.
External diameter	33.2	33.5
Depth of corrugation	1.44	1.44
Mean thickness of metal	.378	.362 ins.
Length of corrugation	6	*8 ins.
Length of furnace	36	39.2 ins.

*Approximate.

The furnaces were tested vertically. The point where the permanent deformation reached perceptible amounts was about at 70,000 kg. load (154,000 lbs.) for both furnaces. Above this point the permanent compression of the Fox furnace increased much more rapidly than for the other. Thus, for a permanent compression of 0.001, the respective loads were about 209,000 and 249,000 lbs. Below the 154,000-lb. point, the slope of the deformation curve was flatter for the Fox furnace, indicating its greater "co-efficient of elasticity." The relative compression, on the line of perfect elasticity, was about 28% higher for the Fox furnace. Thus the "elasticities" of the two furnaces are, approximately, inversely proportional to the lengths of corrugation, for equal depths of corrugation. The Fox type of furnace, it will be recalled, has corrugations in which the depressions are of the same shape as the ridges, as in ordinary corrugated steel, while the Morison furnace has narrow rib-like ridges and flatter depressions. The latter is usually considered to have greater transverse strength, but Prof. Bach believes that internal furnaces should have the greatest possible longitudinal elasticity to take up the expansion stresses, and shows by the above-quoted test that the Fox type has the greater elasticity. However, the difference in the depth of corrugation in the two furnaces should be considered.

A STRAIGHT-TUBE WATER-TUBE BOILER, similar to the Rust boiler which was described in Engineering News of Aug. 25, 1904, is manufactured in Germany by F. Gebauer, of Berlin, under the name Garbe straight-tube boiler. The tube-sheets of the upper and lower drums are pressed out around the mouth of each tube so as to give a flat face normal to the axis of the tube. The arrangement of the tubes differs slightly from that of the Rust boiler. In the latter the tubes are staggered transversely, while in the Garbe boiler they form straight transverse rows. This arrangement leaves circular belts of the original shell untouched, thereby adding to the strength, although apparently the result is that the tubes are spaced wider apart.

THE SUPPLEMENTARY PUMPING PLANT of the Lasalle, Ill., water-works, described in our issue of June 30, 1904, is to be extended by duplicating the first unit. The pump is a turbine pump with vertical shaft, belt-driven at the upper end from an automatic high-speed engine. Under test the capacity and efficiency showed up so favorably that the Buffalo Forge Company, of Buffalo, N. Y., who furnished both the pump and the engine, were instructed to build a duplicate outfit to be used as a relay. Both pumps will be placed in the same pit and driven by separate high-speed engines controlled by throttling governors, which enable adjustment of speed to be made while the engine is in motion. These pumps have impellers of the closed type with curved vanes, and have fixed guide-vanes outside the impeller; they are, therefore, true turbine-pumps. Mr. D. W. Mead, M. Am. Soc. C. E., is Consulting Engineer for the Lasalle Water-works.

ELECTRIC HOISTS are in some cases being used for the derricks and material elevators used in the erection of tall buildings, instead of the steam hoists more generally used. The result is a great reduction in noise and dirt. At the First National Bank Building, Chicago, there are steam and electric hoists placed side by side near the sidewalk, and the difference between them in regard to noise and dirt is very evident.

CAST-IRON SHEET-PILING was used on the Zifta Barrage, on the Damietta branch of the Nile. The piling was used to form the sides of a cofferdam. Some of it was in 10-ft. and some in 16-ft. lengths. It was tongued and grooved, 2 ft. 3½ ins. over all, 3½ ins. in maximum thickness, but reduced greatly in thickness by panels on each side. The cutting end of each pile was bevelled 10 ins. in its 27½ ins. of width, so as to give a chisel point on one side. The bevel at the opposite side was rounded. Ordinary pile-driving machines were used to sink the piles, employing a cast-iron monkey. The joints between the piles were grouted with neat cement. The same kind of piles were used on the Assiut Barrage. The Zifta Barrage was recently described in detail in a paper presented to the Institution of Civil Engineers by Mr. F. A. Hurley, Assoc. M. Inst. C. E. (See Vol. CLVI., Part II., 1903-4.)

EXPERIMENTS ON THE PURIFICATION OF BREWery wastes were described by H. Maclean Wilson in a paper read before the recent annual congress of the Sanitary Institute at Glasgow. The experiments were made in 1903 at the Old Brewery, Rotherham, and included a septic tank, a chemical precipitation tank, double contact beds, percolating filters, and a filter composed of gravelly and loamy soil for the final treatment of effluent from the percolating filters. The conclusions drawn from the experiments were in favor of chemical precipitation and double percolating filters, followed by "a shallow strainer of sand for the removal of suspended matters." To avoid acid fermentation the precipitation tanks should be relatively small. The filters, on the other hand, should be relatively large enough to allow a moderate rate of operation.

REVENUES FROM THE FORESTS owned by the government of Saxony (Germany) have been increasing steadily since 1817, and for the years 1899-1901 they aggregated $2,128,500. The area of these forests is 434,896 acres, with 35,500,000 yds. of standing timber, an increase during the past 50 years. It is said that this increase is due largely to the scientific care with which the forests have been developed. Schools for forestry have been improved and capable government officials have been placed in charge of the administration of the forests. The expenditures for the construction and improvement of forest roads to facilitate the transportation of timber have been considerable; from 1884 to 1893 no less than $115,000 were expended annually for this purpose, and in 1903 this sum had grown to $175,000. Experience has shown these investments to have been wise, and productive of high returns on the capitalization.